PROJECT MARINUS

Initial Feasibility Report

February 2019

ARENA
Australian Government
Australian Renewable Energy Agency

TasNetworks
Delivering your power

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Executive Summary

Australia's energy sector is undergoing unprecedented change, quickly transitioning to cleaner energy sources. New generation is increasingly from variable renewable sources such as wind and solar that are not always available on-demand to meet customer energy needs. Australia's large fleet of synchronous coal-fired generators is starting to retire as plant reaches end of life. To ensure Australia's energy supply is affordable, reliable, secure and cleaner into the future, the National Electricity Market (**NEM**) will need diverse generation and load sources, storage and dispatchable on-demand energy. Greater interconnection between Tasmania and the rest of the NEM – the potential Marinus Link – can support these outcomes and provide significant economic stimulus to regional communities in Tasmania and Victoria.

Key messages

Based on work done to date, our initial feasibility study has found that:

- A second Bass Strait interconnector – Marinus Link – would be a strategic interconnection investment providing NEM-wide economic benefits. Marinus Link provides value by enabling substitution of lower cost Tasmanian hydro generation, pumped hydro storage and competitive renewable resources for higher cost thermal and renewable generation in mainland regions of the NEM. It enables cost-effective dispatchable on-demand generation and a range of power system stability services to firm[1] and support the NEM's transition to renewable energy resources.
- Marinus Link will be technically feasible for a capacity of 600 megawatts (**MW**) or 1200 MW delivered in two 600 MW stages. This staging reflects:
    - design considerations, so that no more than 600 MW is lost in a credible contingency event[2]; and
    - the expected manufacturing and construction durations.
- Routes have been identified that are feasible and likely to obtain environmental and planning approvals. The favourable routes connect a converter station in the Sheffield or Burnie area in north-west Tasmania by high voltage direct current (**HVDC**) cable to a converter station in Victoria's Latrobe Valley.
- The economic feasibility of Marinus Link is dependent on assumptions made about future

[1] Firming, in relation to variable generation sources such as solar or wind, is the action of adding additional power from a separate dispatchable on-demand source that can compensate for the potential lack of output from a variable generator when the power is needed.
[2] Credible contingency event: the failure or removal from service of one or more elements of the power system, that is considered reasonably possible in the surrounding circumstances e.g. loss of a single generator, load or circuit in the network, loss of multiple circuits in a transmission corridor in the presence of a severe bushfire.

developments in the NEM and timing of Marinus Link being in service, with a range of possible outcomes.

- The Australian Energy Market Operator's 2018 Integrated System Plan (**ISP**) considered Marinus Link as an investment in the mid-2030s, and worth further investigation to determine optimal timing. This Initial Feasibility Report has focused on understanding the circumstances where the link would be economically feasible from the 2020s.
- The largest single influencing factor in the economic feasibility and timing of Marinus Link is the trajectory of coal-fired generation retirement in the NEM. A key value driver for Marinus Link is its ability to supply on-demand renewable power to the NEM as large-scale retirement of coal-fired generation occurs. There are plausible circumstances where Marinus Link could be economically feasible from the mid-2020s.
- The benefits of Marinus Link are likely to be greater than costs when approximately 7000 MW of the NEM's present coal-fired generation capacity retires, which could occur from the mid-2020s (with early retirement) to the mid-2030s (with retirement at the end of design life). Coal-fired generators could retire ahead of design life for emissions reduction or economic reasons.
- Most energy market benefits would be realised in mainland NEM regions, with Marinus Link supporting lower cost energy outcomes to meet mainland NEM customer demand.
- Contributions from Government(s) and/or modifications to the present pricing framework would support fair pricing outcomes for Tasmanians from a regulated Marinus Link, recognising that energy market benefits are principally to mainland NEM customers.
- Marinus Link would unlock broader economic value in regional communities in Tasmania and Victoria. In Victoria construction and operation of Marinus Link is estimated to provide economic stimulus of over $1 billion, with more than 900 direct and indirect jobs during peak construction. In Tasmania, Marinus Link would provide economic stimulus directly, and also from the new investment in renewable energy projects that it enables. In Tasmania construction and operation of Marinus Link is estimated to provide economic stimulus of over $600 million, with more than 500 direct and indirect jobs during peak construction and thousands more in related projects.
- Marinus Link is estimated to have a capital cost of approximately $1.3 - $1.7 billion for a 600 MW capacity interconnector and approximately $1.9 - $3.1 billion for a 1200 MW capacity interconnector.
- There are a number of matters that will be addressed in future work, including:
    - refinement and update of analysis to date;
    - the service and funding model for Marinus Link; and
    - the pricing arrangements for recovering Marinus Link costs.
- The key findings in this Report support the continuation of the Feasibility and Business Case Assessment work, co-funded by the Australian Renewable Energy Agency (**ARENA**) and TasNetworks, in 2019.
- Given the long lead-time to implement Marinus Link, and the potentially significant benefits, it is

prudent to continue the project as a risk mitigation measure for a transforming NEM. Early commitment to fund activities in the next phase – the Definition and Approvals phase – would allow a number of long lead-time items to progress. This would support a 'shovel ready' project able to move to the Delivery phase by 2021 or when required. Supporting land and easements should be secured.

A glossary of terms, acronyms and references has been included (Chapter 12) to aid readers who may not be familiar with the electricity market and the range of technical terms and concepts, reports and analysis considered in this Report.

Context

The scale of transition underway in the NEM is unprecedented. Since 2012, the NEM has witnessed the retirement of 4260 MW of coal-fired synchronous generation while variable wind and solar renewable capacity has grown to 9702 MW[3]. With an additional 15,000 MW of coal-fired generation predicted to retire by 2040[4], diverse solutions are required to ensure customer energy needs are met securely and reliably into the future, including local generation and battery storage, as well as large-scale renewables and pumped hydro storage. Greater interconnection between Australia's energy resources is also part of the solution to allow the best use of available energy resources across the NEM. A second interconnector between Tasmania and Victoria has been highlighted as one of the many elements to ensure that the NEM's transmission network is able to evolve in tandem with the challenges presented to the national power system.

In December 2017 Project Marinus was established by TasNetworks, with funding support from ARENA and the Tasmanian Government, to complete a detailed Feasibility and Business Case Assessment of a second Bass Strait interconnector, known as Marinus Link. This link would operate in addition to the existing Bass Strait interconnector, Basslink. An indicative overview of the full project scope and timing is summarised in Figure 1. Timing will depend on a number of factors, including the capacity of the interconnector, a positive economic assessment and business case, and securing funding and approvals to proceed through each phase.

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[3] Figure reflects the estimated rooftop photovoltaic output of 4917 MW in 2017 (AEMO, *Operational and market challenges to reliability and security in the NEM*, March 2018) and the committed large-scale renewable wind and solar photovoltaic capacity of 4785 MW (AEMO, *Generator Information Page*, accessed 19 July 2018).

[4] AEMO, *Integrated System Plan for the National Electricity Market*, July 2018, p.21

Figure 1 Project overview

In July 2018, the Australian Energy Market Operator (**AEMO**) released its inaugural ISP, recognising the magnitude of change underway and the need for an integrated plan to guide future investments. The ISP highlights that increased investment in an interconnected grid provides the flexibility, security, and economic efficiency associated with a power system designed to take maximum advantage of existing resources. Interconnection also manages the risk of uncontrollable climate effects such as bushfires, droughts (both water and wind) and heatwaves[5].

In August 2018 AEMO released its 2018 Electricity Statement of Opportunities (**2018 ESOO**) highlighting emerging risks of unserved energy[6] across New South Wales, South Australia and Victoria as large, dispatchable on-demand generators continue to retire and demand patterns change[7]. For Victoria the 2018 ESOO predicts that in the absence of new investment, the reliability standard may not be met in 2018-19 and will no longer be met by 2021-22 in some credible scenarios[8]. In a transforming NEM, greater interconnection between Victoria and Tasmania could play a role in addressing this risk and the other emerging risks identified in the 2018 ESOO – resulting in the delivery of cleaner energy that is also affordable, reliable and secure. Infrastructure Australia has recognised a second Bass Strait interconnector as a priority initiative that would provide national benefits[9].

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[5] AEMO, *Integrated System Plan for the National Electricity Market*, July 2018, p.6
[6] Unserved energy is energy that customers desired but could not be supplied (e.g. due to a blackout)
[7] AEMO, *Electricity Statement of Opportunities 2018*, p.3
[8] AEMO, *Electricity Statement of Opportunities 2018*, p.74
[9] Infrastructure Australia, *Infrastructure Priority List*, November 2018 (https://ia-priority-list.herokuapp.com/pdf)

Initial Feasibility study findings

This Report presents the outcome of the initial feasibility study, and conveys the findings of the analysis undertaken on a second Bass Strait interconnector. The feasibility of Marinus Link has been assessed considering technical, environmental, planning and economic matters. Our assessment of each of these matters is summarised in the following sub-sections.

Technical Feasibility

Technical analysis to date indicates that Marinus Link will be able to support power transfers of up to 1200 MW securely and reliably between Tasmania and Victoria, in addition to the existing Bass Strait interconnector. A 1200 MW capacity link can be designed so that the largest credible contingency associated with the interconnector is limited to loss of 600 MW.

Technical analysis takes into consideration early modelling of credible contingencies and foreseeable future system developments. Further analysis to confirm this initial assessment will be undertaken, including using real time simulations presently under development. This further work will clarify the arrangements required to successfully integrate the interconnector into the power system.

A number of key technology choices need to be made in designing an interconnector. However, HVDC is the only suitable interconnector technology able to transfer the required power over a distance of 250 to 300 km across Bass Strait. Voltage source converter technology is the preferred option for the alternating current to direct current conversion required by Marinus Link.

Given the manufacturing and construction durations, the earliest a 600 MW link could be in service is the mid-2020s. A 1200 MW link would most likely be delivered in two 600 MW stages – the first 600 MW commissioned by the mid-2020s and the full capacity two to three years later. This staging reflects design considerations, so that no more than 600 MW is lost in a credible contingency event, and also expected manufacturing and construction durations.

Environmental and planning approvals

To be able to deliver Marinus Link, environment, land use planning and heritage approvals will be required across Commonwealth, Victorian and Tasmanian jurisdictions. Based on assessment to date, these external approvals are achievable for the favourable route options.

Route options

A number of possible route options have been assessed, with favourable routes identified taking into consideration environmentally sensitive areas, high value land uses and cultural heritage. The favourable routes for a 600 MW to 1200 MW Marinus Link are for a converter station in the Sheffield or Burnie area in north-west Tasmania linked by HVDC cable to a converter station in the Latrobe Valley in Victoria.

Identification of the favoured route is expected in the first quarter of 2019. Indicative favourable routes are reflected in Figure 2.

Figure 2 Indicative routes for Marinus Link

Feasible routes have been identified that have favourable technical and economic characteristics and which are likely to achieve environment, planning and cultural heritage approvals, land access, consents and acquisition.

The analysis undertaken highlights that preserving corridors for interconnection is important, as key areas are becoming more constrained by urban, rural residential and rural living developments. It is prudent to secure land access rights for potential interconnector routes in the short term before the corridors become constrained.

Economic assessment

The economic feasibility of Marinus Link is dependent on assumptions made about the future NEM and timing of the interconnector being in service, with a range of possible outcomes. There are plausible circumstances where Marinus Link can provide greater economic benefits than its costs. The most influential factors in the economic worth[10] of Marinus Link are the timing of the retirement of coal-fired generation, the timing of Marinus Link itself, and construction of complementary projects such as Snowy 2.0.

Under some circumstances Marinus Link is likely to deliver positive economic worth in the mid-2030s. This agrees with the result identified by AEMO in its ISP. The ISP also stated that Marinus Link timing warrants review as more information is obtained[11]. TasNetworks has sought to identify the circumstances in which Marinus Link could deliver positive economic worth in the 2020s. Circumstances were identified in which Marinus Link is likely to deliver positive economic worth from the mid-2020s.

The timing is primarily linked to the value that Marinus Link provides to the NEM as coal-fired generation retires. Different timing of large-scale retirement of coal-fired generators in the NEM therefore affects the optimal timing of Marinus Link. If Australia's existing coal-fired generators remain in service until the end of their design lives, Marinus Link is likely to deliver a positive economic worth in the mid-2030s. Further work will be undertaken in 2019 to consider this assessment.

AEMO's ISP modelling recognises that existing coal-fired generators may retire earlier than design life due to higher emissions reduction targets, a conclusion supported by TasNetworks' modelling for this Report. Other factors may also contribute to accelerated retirement, including generator reliability issues and/or energy market drivers that affect the economic viability of generators. AEMO highlights the increasing reliability issues experienced by a number of coal-fired generators in recent years, reflective of the aging fleet[12].

[10] The economic worth is the present value of the benefits of Marinus Link minus the present value of its costs.
[11] AEMO, *Integrated System Plan for the National Electricity Market*, July 2018, pp.85 and 87
[12] AEMO, *2018 Electricity Statement of Opportunities*, August 2018, pp.6, 21 and 48

With retirement of 7000 MW approximately of the NEM's presentcoal-fired generators by the end of the 2020s, the economic worth of Marinus Link is expected to be positive from the mid-2020s approximately:

- $490 million for a 600 MW capacity link commissioned in the mid-2020s; or
- $480 million for a 1200 MW capacity link built and commissioned in two stages from the mid-2020s.

Marinus Link provides economic worth by facilitating the development of Tasmania's lower cost, dispatchable, on-demand energy resources. This delivers economic benefits for the NEM as a whole by avoiding the need to operate higher cost, higher emission generation resources such as gas-fired plant. The additional interconnection capacity also contributes to increased supply reliability and power system security in mainland NEM regions, and provides resilience benefits to both mainland NEM regions and Tasmania in the event of an extended outage of Basslink.

The economic feasibility and interconnector timing results are influenced to a lesser extent by other factors such as the presence of Snowy 2.0 and state-based renewable energy targets, which both act to dampen the benefits delivered by Marinus Link. Analysis suggests that accelerated coal-fired generation retirement, such as under a high emissions reduction target, or potentially as a result of state-based renewable energy targets, would see Marinus Link providing positive economic worth, even with Snowy 2.0 in service. Further modelling in 2019 will update and refine this analysis.

In addition to supporting good outcomes for electricity customers, Project Marinus can support construction and operations jobs and broader economic stimulus in regional Australian communities. In Victoria construction and operation of Marinus Link is estimated to provide economic stimulus of over $1 billion, with more than 900 direct and indirect jobs during peak construction. In Tasmania, Marinus Link would provide economic stimulus directly, and also induce new investment in renewable energy projects. In Tasmania construction and operation of Marinus Link is estimated to provide economic stimulus of over $600 million, with more than 500 direct and indirect jobs during peak construction. The project can support decades of investment in Tasmania's high quality, dispatchable on-demand renewable resources and provide services that can 'firm' the significant variable renewable generation investment elsewhere in the NEM.

Project cost recovery

Marinus Link could potentially proceed as a regulated service or a merchant service, or a hybrid of the two[13]. Should the project proceed, it will be important that the framework to recover the costs for interconnector services fairly allocates costs to those who benefit from the services. The present regulated service pricing arrangements are unlikely to achieve this outcome.

13 See Chapter 9 for explanation of regulated, merchant and hybrid.

Successfully passing the regulatory investment test for transmission (**RIT-T**) is the present framework for interconnectors to provide regulated services. This framework considers benefits and costs to customers in the NEM. The RIT-T process for the project has commenced, with further work on the detailed RIT-T analysis to continue in 2019. There is a prospect that Marinus Link may successfully pass a RIT-T – including where there are Government contributions such as grants, to recognise broader regional and national benefits.

The RIT-T process aims to promote efficient investment in electricity services for the long-term interests of consumers of electricity. The assessment is focussed on maximising the net economic benefit across the NEM. Successful passing the RIT-T allows a transmission network service provider, such as TasNetworks, to earn revenues as determined by the Australian Energy Regulator (**AER**)[14] through a NEM regulatory determination process. Revenue recovery is based on transmission pricing rules that largely result in project cost recovery determined by network usage from customers in the region where assets are located. This regional pricing does not align with the NEM wide net economic benefits identified through the RIT-T process.

Analysis shows that the current regulated pricing framework would see Tasmanian customers' transmission charges increase disproportionately as a result of Marinus Link, relative to the benefits received. Therefore, TasNetworks considers that the link should only proceed as a regulated service if there are contributions from Government and/or the present pricing framework is modified, recognising that Marinus Link benefits are principally to mainland NEM customers. TasNetworks will actively work with policy makers, regulators and market bodies to seek this outcome.

Stakeholder and community engagement

Stakeholder and community engagement is being undertaken for Project Marinus to connect, inform, consult and collaborate with project stakeholders. This engagement supports TasNetworks' understanding of stakeholder feedback about Project Marinus, and implications for the Feasibility and Business Case Assessment, and future project phase considerations.

In July 2018 TasNetworks released the first consultation document under the RIT-T process – the Project Specification Consultation Report – to consider a second Bass Strait interconnector. Submissions closed in late October 2018.

[14] For a transmission network service provider (**TNSP**), passing the RIT-T allows the asset's cost to be included in its regulatory asset base (**RAB**). The RAB for a transmission system owned, controlled or operated by a TNSP is the value of those assets that are used by the TNSP to provide prescribed transmission services, but only to the extent that they are used to provide such services, National Electricity Rules, cl. 6A.6.1.

Submissions received covered a number of broad themes and reinforced the requirement for rigorous analysis and effective consultation to ensure good customer outcomes. Some of the matters raised as part of the RIT-T consultation are not able to be considered under the present RIT-T legal framework, but are relevant to considering the feasibility and business case of Marinus Link.

This Report summarises feedback on the RIT-T consultation, and includes information to address a number of matters raised in the RIT-T submissions[15]. Further information will be developed and shared as the Feasibility and Business Case Assessment, including the RIT-T process, continues.

Next steps

The findings from this Report will be shared with a range of interested stakeholders, and feedback requested. Chapters 10 and 11 outline our stakeholder and community engagement processes, provide our contact details and seek feedback, including to specific questions that can inform TasNetworks' future activities.

The analysis so far shows that there are plausible circumstances where Marinus Link could be economically feasible from the mid-2020s. Therefore, work will continue in 2019 to progress the analysis in this Report, and undertake additional engagement and analysis, including as part of the RIT-T process. Further work will include more detailed assessment of the service, funding and pricing models needed to inform the Final Feasibility and Business Case Assessment Report.

Work will also progress to secure funding for the Definition and Approvals phase to allow long lead time activities, such as technical design and land use planning approvals to be undertaken. This would support a 'shovel ready' project, able to move more quickly to the Delivery phase by 2021 or when required. Work should also continue to secure land and easement rights, to preserve corridors for future Bass Strait interconnection.

Commitment to the delivery phase will require a range of preconditions to be met, culminating in a final investment decision.

Further information on the next steps is set out in each chapter.

[15] See Appendix 4.

1. Introduction

This chapter provides the rationale behind this Report and gives some context around the proposed interconnector, Marinus Link.

The transmission of electricity between states – commonly referred to as interconnection – enables greater sharing of Australia's diverse energy sources. The development of additional interconnection capacity between states of the NEM is recognised as a crucial step in ensuring a cost-efficient transition of the national power system. The need to develop the transmission and generation capacity of the NEM has been well detailed by recent state and federal reviews[16], as well as by analysis completed by AEMO[17]. These reviews all identified that a coordinated approach is required to ensure the best outcomes for electricity consumers, as the way electricity is produced, consumed and transported throughout the NEM continues to change.

The investigation of a second interconnector between Tasmania and Victoria has been highlighted as one of the many elements needed to ensure that the NEM's transmission network is able to evolve in tandem with the challenges presented to the national power system.

In December 2017 Project Marinus was established by TasNetworks, with funding support from ARENA and the Tasmanian Government, to complete a detailed Feasibility and Business Case Assessment for a second Bass Strait interconnector – known as Marinus Link. The work builds on the foundations of work undertaken by Dr John Tamblyn, which resulted in the report titled Feasibility of a Tasmanian Second Interconnector: Final Study–April 2017 (the Tamblyn study)[18].

The Project Marinus work underway includes:

- an Initial Feasibility Report (this Report); and
- the Final Feasibility and Business Case Assessment Report, forecast to be released in December 2019.

Project Marinus is considering an interconnector with capacity of 600 MW or 1200 MW (delivered in two 600 MW stages). Marinus Link would operate in addition to Basslink.

To deliver Marinus Link, a more detailed Definition and Approvals phase would be required to establish that there is a deliverable project with a supporting positive business case. If this is achieved, then a Delivery phase would follow, also subject to securing necessary funding and approvals.

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16 Dr Alan Finkel et al, *Independent review into the future security of the National Electricity Market: Blueprint for the future*, June 2017; Dr John Tamblyn, *Feasibility of a second Tasmanian Interconnector, Final Study*, April 2017
17 AEMO, *Integrated System Plan for the National Electricity Market*, July 2018, p.6
18 Dr. Tamblyn's review undertook a range of analysis and recommended that "the Tasmanian Government develop a detailed business case for a second Tasmanian interconnector" should any of the preconditions specified in the report be met.

Once in service, an interconnector would move into the Operations phase, with an expected service life of at least 40 years. For a 1200 MW interconnector, the first 600 MW stage would be commissioned and commence operations, with the second 600 MW phase delivered and in service two to three years later. An indicative overview of the full project scope and timing is summarised in Figure 3 – recognising that timing will depend on a number of factors, including the capacity of the interconnector and securing funding and approvals to proceed through each phase.

Figure 3 Project overview

A project of this scale and significance brings a number of risks to manage throughout the lifecycle. TasNetworks could undertake some, or all, of these phases. The work may also be progressed by other parties, in partnership with TasNetworks or independent of TasNetworks.

Regardless of the model by which the project could proceed, TasNetworks will retain the responsibilities of Tasmania's transmission network service provider (**TNSP**) – responsible for transmission planning and any shared network upgrades in Tasmania, ensuring a National Electricity Rules (**Rules**) compliant connection of any new interconnector to the existing Tasmanian shared network, and transmission pricing in Tasmania. Similarly, AEMO will have this role in Victoria as the jurisdictional planner and coordinating TNSP for augmentation planning and pricing in Victoria. AEMO will also have a critical role in future project phases, with national transmission planning responsibilities and as market operator for the NEM.

This Report delivers the initial findings of the analysis undertaken to date, paving the way to continue with the next stage of detailed assessment, the Final Feasibility and Business Case Assessment Report, forecast to be released in December 2019.

Should the final assessment support the case for additional interconnection, then a detailed Definition and Approvals phase would be needed before a final investment decision could be made.

This chapter is structured in eight sections:

- 1.1 Australia's evolving power systems – outlines the forecast evolution of Australia's power system.
- 1.2 Addressing the energy trilemma – describes the three main challenges for the future power system and how Marinus Link helps address them.
- 1.3 TasNetworks' role – details why TasNetworks is carrying out this Feasibility Assessment study.
- 1.4 ARENA's role – details ARENA's role in this Feasibility Assessment.
- 1.5 Knowledge sharing – describes the approach adopted to share key findings.
- 1.6 Interconnector experience – summarises national and international interconnector experience.
- 1.7 Bass Strait interconnector studies – describes earlier reports considering further interconnection between Tasmania and Victoria as context for this Report.
- 1.8 The Initial Feasibility Report – sets out the structure of this Report.

1.1. Australia's evolving power systems

The scale of transition underway in the NEM is unprecedented. Since 2012, the NEM has witnessed the retirement of 4260 MW of coal-fired synchronous generation while variable wind and solar renewable capacity has grown to 9702 MW[19].

The ISP recognises the magnitude of change underway and the need for an integrated plan to guide future investments. Thermal coal and gas-fired generators are starting to retire across the NEM, with an additional 15,000 MW of generation predicted to retire by 2040 – this is equivalent to around one-third of the total energy consumed in the NEM. In addition to providing critical energy production and dispatchable on-demand power, these conventional (synchronous) generators provide essential grid security services to the NEM, such as inertia, system strength, and frequency control[20]. Figure 4 shows the coal-fired dispatchable on-demand generation forecast to retire under the neutral and high emissions reduction scenarios in the Ernst & Young (**EY**) market modelling[21].

[19] Figure reflects the estimated rooftop photovoltaic output of 4917 MW in 2017 (AEMO, *Operational and market challenges to reliability and security in the NEM*, March 2018) and the committed large-scale renewable wind and solar photovoltaic capacity of 4785 MW (Generator Information Page, AEMO, accessed 19 July 2018).
[20] AEMO, *Integrated System Plan for the National Electricity Market*, July 2018, pp.4, 21
[21] Based on EY Market Modelling, see Appendix 1.

Figure 4 Retirement of coal-fired generation in neutral and high emissions reduction scenarios[22]

AEMO's ISP modelling forecasts that over the next two decades the energy mix in the NEM will be transformed:

> *'…from one dominated by coal-fired generation to one with portfolios…of technologically diverse variable renewable generation sources supported by increased transmission and energy storage solutions[23].'*

[22] Based on EY Market Modelling, refer to Chapter 6 for more detail.
[23] AEMO, *Integrated System Plan for the National Electricity Market*, July 2018, p.30

ISP modelling also forecasts:

'A strong role for energy storage that can shift renewable energy production and provide capacity firming support during peak load conditions to support dispatchability of this future energy mix[24].'

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and that there will be:

'…increasing value for strengthening interconnection between regions to meet an increasingly volatile demand across the NEM and take advantage of the diversity of renewables across regions as well as efficiently sharing resources across regions[25].'

The ISP's consideration of the medium and longer-term transformation of the NEM supports the need for infrastructure developments such as pumped hydro storage and Marinus Link, as well as Snowy 2.0 and supporting transmission development proposals.

The ISP indicates that a new interconnector between Tasmania and mainland Australia is one of many transmission investments required to facilitate the development of Australia's renewable energy zones, which are strategic locations able to host large amounts of cost-competitive renewable generation capacity.

AEMO identifies that when existing gas and coal-fired thermal generation reaches the end of its technical life and retires, the most cost-effective replacement of its energy production, based on current cost projections, is a portfolio of utility-scale renewable generation, energy storage, distributed energy resources, flexible thermal capacity including gas-powered generation, and transmission[26].

The ISP highlights that increased investment in an interconnected grid provides the flexibility, security, and economic efficiency associated with a power system designed to take maximum advantage of existing resources. Interconnection also addresses the risk of uncontrollable climate effects such as bushfires, droughts (both water and wind) and heatwaves[27].

Tasmania has world-class renewable energy resources – in addition to a solar and high-quality wind resource, Tasmania has existing hydro-electric generation, with potential for further cost-effective

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[24] AEMO, *Integrated System Plan for the National Electricity Market*, July 2018, p.30
[25] ibid
[26] AEMO, *Integrated System Plan for the National Electricity Market*, July 2018, p.5
[27] AEMO, *Integrated System Plan for the National Electricity Market*, July 2018 p. 6

hydro-electric generation and storage. Hydro-electricity has the advantage of providing renewable energy that is dispatchable on-demand, with generators that can also provide inertia, system strength, and frequency control services. Analysis undertaken by Hydro Tasmania to consider Tasmania's potential in the future NEM found that the coordinated development opportunity of pumped hydro storage, wind and additional interconnection was cost competitive against all other realistic options for the future energy system[28].

In combination, the development of a second interconnector, optimisation of Tasmania's existing hydro resources and pumped hydro potential, and further development of Tasmanian and Victorian renewable energy zones, can be part of the range of solutions needed to support positive customer outcomes in a fast moving and complex energy sector.

AEMO's 2018 Electricity Statement of Opportunities highlights emerging risks of unserved energy across New South Wales, South Australia and Victoria as large, dispatchable on-demand generators continue to retire and demand patterns change. Figure 5 shows the forecast unserved energy in New South Wales, South Australia and Victoria in the next 10 years based on neutral demand forecasts[29]. AEMO projects a negligible level of unserved energy in Queensland and Tasmania, with both regions having a significant surplus in generation capacity.

[28] Hydro Tasmania, *Battery of the Nation – Analysis of the future National Electricity Market*, April 2018, p.2
[29] AEMO, *Electricity Statement of Opportunities*, August 2018, p.7

Figure 5 Forecast unserved energy outcomes in New South Wales, South Australia and Victoria[30]

For Victoria, AEMO's 2018 Electricity Statement of Opportunities forecasts:

- Without action to procure additional reserves, the risk of load shedding will remain high for summer 2018-19, with Victoria at risk of exceeding the reliability standard.
- Unserved energy will decline slightly over the following two years, due to flat peak demand projections and an increase in renewable generation.
- As forecast peak demands increase, the level of unserved energy will start to rise. In the absence of new investment, the reliability standard will no longer be met by 2021-22 in some credible scenarios.
- Victoria will share a reliability gap with South Australia, with a gap of 40 MW across the two regions from 2022, increasing to 460 MW by 2028, with most unserved energy occurring in summer between 4.00 pm and 7.00 pm[31].

In a transforming NEM greater interconnection between Victoria and Tasmania can play a role in addressing these emerging risks, delivering cleaner energy that is also affordable, reliable and secure. AEMO expects that the economic justification behind an additional Bass Strait interconnector would be driven primarily by the long-term need for energy storage across the NEM, and the projected replacement of energy produced by coal-fired generation in Victoria. Additional benefits would include accessing high-quality wind resources

[30] AEMO, *Electricity Statement of Opportunities*, August 2018, p.7
[31] AEMO, *Integrated System Plan for the National Electricity Market*, July 2018, p.88

in Tasmania and improving hydro efficiencies by repurposing and refurbishing existing assets[32]. The economic analysis in this Report aligns with AEMO's contention.

AEMO signalled its intention to engage more closely with stakeholders to understand the potential to leverage the existing Tasmanian hydro-power system, understand the cost differences in storage between NEM regions[33] and the optimal timing of investment in supporting transmission interconnection[34]. Hydro Tasmania and TasNetworks continue to engage with AEMO in this regard. Analysis undertaken subsequent to the ISP modelling, and outlined in this Report, reinforces that a second Bass Strait interconnector can provide a number of benefits to a transforming NEM.

1.2. Addressing the energy trilemma

The challenges and opportunities presented by the changing energy landscape require coordinated planning. To ensure consumer's interests are best met, the NEM requires a balanced approach to the reliability, affordability and emissions of the energy market – the so-called energy trilemma.

Increasing affordability for energy consumers

Efficient investment in generation and transmission capacity is a cornerstone of The National Electricity Objective. A second Bass Strait interconnector can proceed as a regulated investment where it provides benefit to energy consumers across the NEM by delivering greater value than costs when contrasted with all other credible investment options[35].

> "*to promote efficient investment in, and efficient operation and use of, electricity services for the long term interests of consumers*" – **extract from the National Electricity Objective**

The primary source of cost savings enabled by Marinus Link is supporting access to lower cost generation and storage resources, thereby reducing energy market costs and prices. Greater benefits across the NEM can be realised due to the differing supply and demand characteristics of each region[36].

Marinus Link will proceed where it delivers sufficient benefit to customers in the NEM. A challenge is ensuring that the network cost increases associated with Marinus Link are paid for by those customers who benefit from the services. Customers can include both generation and load customers.

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[32] AEMO, *Integrated System Plan for the National Electricity Market*, July 2018, p.88
[33] AEMO, *Integrated System Plan for the National Electricity Market*, July 2018, pp.9, 76, 85, 88
[34] AEMO, *Integrated System Plan for the National Electricity Market*, July 2018, p.85
[35] The RIT-T requires that investment costs are outweighed by benefits in order to achieve regulated status as a protection for consumer interests.
[36] For example, generation patterns are diverse between Tasmania and the rest of the NEM as mainland NEM has peak demand during summer, while Tasmania's occurs in winter

There is a prospect that Marinus Link may successfully pass a RIT-T and provide regulated services. However our analysis shows that the current regulated pricing framework would see Tasmanian customers' transmission charges increase disproportionately as a result of Marinus Link, relative to the benefits received. This would result in inequitable network pricing outcomes for Tasmanian customers, with the project therefore unlikely to be supported.

Therefore, Marinus Link should only proceed as a regulated service if the pricing outcomes recognise that Marinus Link benefits are principally to mainland NEM customers. This outcome could be achieved by contributions from Government, such as grants to recognise national benefits, and/or by modifying the present Rules pricing framework so that the costs are not disproportionately borne by Tasmanian customers.

Improving security and reliability of the grid

The power system security[37] and supply reliability[38] challenges faced across the NEM are growing, with a range of measures being put in place to support improved power system security and supply reliability.

Although Tasmania benefits from a high proportion of dispatchable on-demand hydropower generation, its ability to supply hydroelectric energy to consumers can be affected by long-term rainfall patterns. In response to the Tasmanian Energy Security Taskforce report recommendations (discussed in section 1.7) the Tasmanian Government has implemented a number of measures so that Hydro Tasmania manages its portfolio of generation resources to meet Tasmanian energy security[39] needs. Wind farms presently under construction in Tasmania will also help to meet Tasmania's energy needs.

Further interconnection with the mainland NEM will provide Tasmania and Victoria with increased resilience in the event of a failure of Basslink, such as the one experienced from December 2015 to June 2016. This failure was estimated to have cost between $140 million and $180 million[40]. Further interconnection will also release the latent potential in the existing hydro-electric schemes, with Tasmanian energy security instead supported by greater interconnection.

Victoria and mainland Australia are evolving towards lower levels of supply reliability, due to changes in generation composition. In particular, the decreasing level of coal-fired generation and increasing level of renewable generation are resulting in lower levels of dispatchable on-demand electricity in the NEM. Basslink, supported by dispatchable on-demand Tasmanian generation, is one of a number of resources already used to meet Victorian peak power needs.

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[37] In this Report power system security is used to mean operation of the power system within its technical limits (frequency, voltage, etc.) such that it will maintain stable operation following a contingency
[38] In this Report supply reliability is used to mean maintaining sufficient capacity (generation, network, and demand response) to meet customer power demands in the short-term
[39] In this Report the term energy security refers to the certainty of being able to supply customers' energy needs in the medium and long-term.
[40] Hydro Tasmania, *Annual Report,* 2016

Power system security and supply reliability issues have grown in focus with a number of large system events – including the South Australian system black in 2016. In 2018, an interconnector trip between Queensland and New South Wales resulted in a range of load-shedding across the NEM to maintain power system stability. Both of these events resulted from non-credible contingencies. The combination of extreme weather conditions, new generation technologies and the growing challenge AEMO faces in forecasting available generation and load mean that these non-credible events are occurring more often.

In response, a suite of new Rules has been introduced by the Australian Energy Market Commission (**AEMC**) to improve system stability, system strength and reliable customer supply[41]. These include new generation requirements and new obligations on transmission businesses.

By providing access to dispatchable on-demand power and a range of power system stability services, Marinus Link can support a more secure and reliable national grid. Advances in HVDC transmission technologies mean that Marinus Link will be more controllable and capable of providing power system stability services beyond what is achievable from Basslink[42]. Pumped hydro storage projects enabled by Marinus Link could also support power system stability, as pumped hydro pumps may have synchronous motors and generators that provide this support.

Reducing emissions of the power system

In 2015 Australia committed to the Paris Climate Agreement, setting an emissions reduction target of between 26 and 28 per cent on 2005 levels by 2030. To meet this target, in tandem with the federal Renewable Energy Target and state-based targets, a significant amount of renewable energy capacity will be integrated into the national grid.

All renewable resources are not created equal. Hydro and pumped hydro storage benefit from being renewable and dispatchable on-demand energy sources. They also use synchronous generators that support the stability of the power system.

Pumped hydro storage can time shift variable renewable wind and solar resources: storing it when it is being generated but not needed to meet customer demand, and able to release it when energy is needed to meet demand.

Tasmania already has the cleanest energy in the NEM, with energy demands primarily met from renewable hydro and wind resources. Marinus Link can pave the way for further development of Tasmanian renewable

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[41] e.g National Electricity Amendment (Managing power system fault levels) Rule 2017; National Electricity Amendment (Managing the rate of change of power system frequency) Rule 2017; National Electricity Amendment (Generator technical performance standards) Rule 2018; Reliability Panel (AEMC) Review of the Frequency Operating Standard, 14 July 2017

[42] Basslink commenced commercial operation in 2006. Basslink uses monopole HVDC LCC technology, which has limited ability to provide power balancing and FCAS compared to the technology proposed for Marinus Link.

resources, including the significant high-quality wind potential (with a higher capacity factor than most mainland NEM generation), as well as cost-competitive pumped hydro storage capacity of up to 4.8 gigawatt (**GW**)[43]. By facilitating more energy from renewable generation and less energy from thermal generation, Marinus Link would assist Australia achieving its greenhouse gas reduction targets at a lower cost. Marinus Link supports a reduction of at least 10 Million tonnes of greenhouse gases over 25 years. By enabling a shared access to diversified and complementary renewable resources, such as Tasmania and Victoria's wind and solar, and cost-competitive pumped hydro storage, Marinus Link can improve the reliability and cost competitiveness of the NEM's renewable generation, benefiting all States and Territories.

1.3. TasNetworks' role

TasNetworks is a state-owned entity that owns, operates and maintains the electricity transmission and distribution networks in Tasmania, and has jurisdictional responsibility for transmission system planning in Tasmania under the National Electricity Law. TasNetworks' shareholding Ministers, with support from the Commonwealth Government, have tasked TasNetworks with assessing the feasibility and business case for a second Bass Strait interconnector.

In undertaking this study TasNetworks has worked with a range of stakeholders. This included AEMO, as the Victorian jurisdictional transmission planner and also as national planner with oversight of transmission planning for the NEM. During initiation and planning of Project Marinus, AEMO seconded a resource to establish the Project Marinus team.

The complex features and ongoing evolution of the Tasmanian power system and Basslink interconnection sees TasNetworks navigate a range of power system security issues that are now emerging globally. TasNetworks is successfully managing a number of technical challenges and delivering secure, reliable, services to its customers, contributing to the lowest regulated standing offer electricity prices, in Australia[44].

Security, reliability and affordability will remain critical areas of focus as the NEM transitions to cleaner energy. TasNetworks' technical expertise and focus on affordable outcomes for customers makes it the ideal organisation to consider the feasibility of a second Bass Strait interconnector, with funding support from the Tasmanian Government and ARENA.

TasNetworks will continue to work closely with AEMO during the execution of the Feasibility and Business Case Assessment for Marinus Link.

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[43] Hydro Tasmania, *Battery of the Nation: Tasmanian pumped hydro storage in Australia's future electricity market*, April 2018
[44] Tasmanian Economic Regulator, *Comparison of Australian Standing Offer Energy Prices*, July 2018

1.4. ARENA's role

ARENA is a Commonwealth Agency, established to accelerate Australia's shift to affordable and reliable renewable energy through the provision of funding, building and support of networks and sharing of knowledge.

TasNetworks is party to a funding agreement under which ARENA has agreed to fund 50 per cent of phase 1 of Project Marinus, covering this initial feasibility study and subsequent Final Feasibility and Business Case Assessment, up to $10 million.

1.5. Knowledge sharing

A key component of Project Marinus is sharing knowledge – to ensure that benefit is derived from work undertaken, whether or not a second Bass Strait interconnector proceeds. TasNetworks developed a Knowledge Sharing Plan in consultation with ARENA and this Report is a key output from that plan.

Other key outputs will be the Final Feasibility and Business Case Assessment Report, the reports required as part of the RIT-T analysis and engagement process, the Real Time Simulator modelling insights for the connected Tasmanian and Victorian power systems and presentations sharing key learnings delivered at workshops, conferences and seminars.

1.6. Interconnector experience

National and international interconnector experience have informed this Report's assessment of Marinus Link. In Australia, a number of interconnectors exist, and a number of new interconnectors are currently under consideration[45]. Europe has significant undersea and land-based interconnection between national electricity grids, with a large number of new HVDC interconnectors under construction and many more in earlier phases of development[46]. Interconnector development is also increasing in America and Asia. This heightened activity reflects that interconnected power systems are able to support the cost-effective integration of new low-cost renewable energy and energy security across broad geographic areas.

Basslink is presently Australia's only subsea HVDC interconnector. It was the longest HVDC cable of its type in the world at the time of construction and is still one of the longest. Basslink has been in service since 2006 and provides significant value to the NEM. Marinus Link would operate in parallel with Basslink, with the increased capacity expected to support energy flows in a transforming NEM.

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[45] Including Marinus Link, RiverLink, SnowyLink, and a link between New South Wales and Queensland.
[46] Ofgem, *Electricity interconnectors*, https://www.ofgem.gov.uk/electricity/transmission-networks/electricity-interconnectors

TasNetworks' predecessor business, Transend Networks Pty Ltd, managed the connection of Basslink to the Tasmanian transmission network, including the development of supporting control schemes. TasNetworks has an ongoing relationship Basslink Pty Ltd, which is a privately-owned market network service provider customer of TasNetworks.

Each phase of the Basslink project lifecycle presented a range of learnings, which have been taken into account in developing this Report. The 2012 Electricity Supply Industry Expert Panel review, commissioned by the Tasmanian Parliament, considered a number of these matters, summarised in Volume II, Part A Basslink: Decision making, expectations and outcomes[47].

In preparing this Report, TasNetworks has taken the opportunity to meet with a number of HVDC interconnector developers, manufacturers, suppliers and regulators in Australia and abroad. This insight has informed the initial feasibility study.

Key learnings from international and national experience include an understanding that the technology now available for undersea HVDC interconnectors has advanced since Basslink was designed and commissioned. New converter station technology and cable technology are increasingly being used, discussed further in Chapter 3. As the technology continues to mature, HVDC interconnectors with increasing transmission capacities and lengths are being developed[48]. New funding and regulatory models are emerging to support international interconnector investment. Changes to market settings and policy arrangements can affect interconnector investment confidence, for example, the business cases for some proposed interconnector projects between the United Kingdom and other European countries have been affected by the 'Brexit' decision.

Critical path items for interconnector delivery include achieving land use planning approvals and the manufacture and installation of HVDC cables. There is a small number of specialised converter station and HVDC cable equipment manufacturers, all based overseas. The increased level of interconnector development activity around the world affects the capacity of suppliers to meet the growing demand for specialist HVDC cable manufacturing and cable laying resources. There are very high quality requirements for the manufacture and laying of subsea cable, given that the asset is positioned under the ocean, and expected to operate reliably for at least 40 years.

Interconnector projects have long lead times and require careful planning across the range of project dimensions. The majority of expenditure is incurred during the project Delivery phase, when equipment is manufactured, installed and commissioned. Throughout the project lifecycle, there are number of risk, time

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[47] Electricity Supply Industry Expert Panel, *An Independent Review of the Tasmanian Electricity Supply Industry, Final Report, Volume II*: http://www.electricity.dpac.tas.gov.au/final_report
[48] For example, WesternLink is a project connecting the transmission systems of England and Wales (National Grid) and Scotland (SP Energy Networks) via a link of 2.2 GW, with a length of over 400 km and a number of longer links are in various phases of development.

and cost trade-offs to consider. Strong project management is essential to deliver successful outcomes and the project must establish sound operating practices to support ongoing interconnector operation.

1.7. Bass Strait interconnector studies

Assessment of further interconnection between Tasmania and Victoria has been considered in various studies over time. This includes:

- 2017 analysis by the Tasmanian Energy Security Taskforce;
- The Tamblyn study commissioned in April 2016 by the Tasmanian and Commonwealth Governments; and
- Hydro Tasmania's 2018 Battery of the Nation, Analysis of the future National Electricity Market report (Hydro Battery of the Nation report).

The Tasmanian Energy Security Taskforce investigated the future security of energy supply in Tasmania, in the wake of the energy supply challenge presented by an extended outage of Basslink and low rainfall inflows to hydro-electric storages. The Taskforce's 2017 report identified the need for additional generation capacity in the State and found that additional interconnection would provide energy security and other benefits to both Tasmania and the rest of the NEM. In the absence of greater interconnection, it recommended a range of measures to support Tasmanian energy security, including more conservative management of hydro-electric storages[49].

The Tamblyn study aimed to understand if a second interconnector would:

- be economically feasible under anticipated future market conditions;
- have long-term benefits to electricity consumers;
- assist in addressing long-term energy security issues; and
- enable investment in renewable energy in the NEM.

The study incorporated work undertaken for the Tasmanian Government, with respect to the capacity, technology and route of a potential second Bass Strait interconnector. The analysis concluded that a second interconnector provided many benefits, but that these were not greater than costs across a range of plausible scenarios. The report recommended that a detailed business case for a second interconnector be developed if one or more of a range of the following preconditions were met:

- AEMO determined that a second interconnector would produce significant positive net market benefits under most plausible scenarios;

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[49] Tasmanian Energy Security Taskforce, *Final Report*, 2017

- an additional interconnector was approved for construction between South Australia and the eastern states; or
- a material reduction in Tasmanian electricity demand occurred.

Two of these proposed preconditions are coming to fruition, with:

- AEMO's acknowledgement in its July 2018 ISP of the potential benefits to the NEM from implementation of Hydro Tasmania's Battery of the Nation recommendations (discussed below) and undertaking to work with TasNetworks and Hydro Tasmania to assess the net benefits from and optimal timing of, investment in a second Tasmanian interconnector; and
- A positive economic assessment by ElectraNet supporting the early implementation of a new interconnector between South Australia and the eastern states.

Hydro Tasmania has considered further Bass Strait interconnection as part of its Battery of the Nation report. This analysis, supported by ARENA funding, highlights Tasmania's potential to contribute net economic benefits to the evolving NEM through the development of Tasmania's cost-competitive hydro, pumped hydro storage and wind power resources. Hydro Tasmania's analysis found that Tasmania's collective renewable generation and storage resources can effectively become a large battery able to store renewable energy and dispatch it to the mainland NEM when required. This potential can only be realised with additional Bass Strait interconnection.

This Report's assessment of Marinus Link considers work undertaken to support these earlier studies and examines a number of aspects of a second Bass Strait interconnector to a greater level of detail.

1.8. The Initial Feasibility Report

The Initial Feasibility Report is structured as follows:

- **Chapter 2** Approach, assumption and methodology – explains the approach taken in this Report.
- **Chapter 3** Technical feasibility of the Project – details the initial technical feasibility performed, including technology section and transmission network integration.
- **Chapter 4** Route selection – outlines the initial route selection process employed in this Report.
- **Chapter 5** Environmental and planning approvals – outlines the potential approvals pathways to support Marinus Link.
- **Chapter 6** Economic feasibility of the Project – describes the initial economic assessment of each project option considered in this Report.
- **Chapter 7** Project plan and cost – describes the project's timeline and the initial project cost estimates.
- **Chapter 8** Ownership models – explores the possible ownership models to be investigated in the Final Feasibility and Business Case Assessment Report.
- **Chapter 9** Project cost recovery and pricing options – considers the impact of cost recovery and the associated pricing options.

- **Chapter 10** Stakeholder and community engagement – details the stakeholder and community engagement activities pertaining to the project's development.
- **Chapter 11** Seeking your feedback – asks questions and provides our contact details.
- **Chapter 12** Glossary and References – explains terms, acronyms and references to aid readers who may not be familiar with the electricity market and the range of technical terms and concepts, reports and analysis considered in this Report.

2. Approach, assumption and methodology

This chapter outlines the general methodology used to assess the feasibility of Marinus Link, with a capacity of either 600 MW or 1200 MW. It describes the approach taken to assess the economic, commercial and technical feasibility of the interconnector project and the basis of the economic modelling and analysis commissioned to support the study.

The Marinus Link Feasibility and Business Case Assessment has two phases:

- The Initial Feasibility Report to be completed in December 2018; and
- The Final Feasibility and Business Case Assessment Report forecast to be released in December 2019.

Where there is a positive economic and business case the project can continue through subsequent phases, namely the project Definition and Approvals, Delivery and Operations phases. Given the long lead times for interconnector projects, the earliest the first 600 MW stage could be in service is the mid-2020s, with the second 600 MW stage able to be commissioned two to three years after.

The following sections outline the chapters of this Report.

2.1. Initial Feasibility Report

In this Report, feasibility has been assessed across a number of dimensions. Principally, the initial assessment considered:

- the technical feasibility to connect Marinus Link to the Tasmanian and Victorian power systems. This includes a focus on the ability to reliably and securely transfer electricity between these regions of the NEM;
- the technical feasibility to construct Marinus Link, given the requirements of the cable, converter stations and supporting transmission connection and upgrades;
- the feasibility of achieving external approvals for the project, taking into account likely routes and associated land use planning, environmental, heritage and social licence considerations; and
- whether investing in Marinus Link will provide economic benefits greater than its costs under credible scenarios.

This Report also identifies a range of commercial considerations for the project, including revenue, financing and pricing matters that will be further assessed in the Feasibility and Business Case Assessment Report.

This Report distils the range of possible interconnector solutions into favourable options for consideration, in terms of:

- route;
- technical configuration; and
- link capacity and timing informed by economic analysis.

The favourable options are informed by supporting analysis and engagement, which are discussed in the chapters to follow. Before the preferred option is finalised, further analysis will be undertaken. This includes considering feedback from stakeholders on this Report.

This Report has been independently reviewed by Dr John Tamblyn with a particular focus on:

- The feasibility assessment approach, assumptions and methodology; and
- The analysis and conclusions on the economic feasibility.

Dr Tamblyn's formal Letter of Review is provided in Appendix 5, with his review concluding:

> *'…that this initial study on the potential for Marinus Link to operate on an economically viable basis in future has been fit for purpose and effective in terms of the methodology adopted, the analysis and findings presented and the general clarity and balance of the reported outcomes.'*

2.2. Final Feasibility and Business Case Assessment

The Final Feasibility and Business Case Assessment is the second part of phase 1, forecast to be released in December 2019. Findings, based on work done to date, support the continuation of this work in 2019 and indicate that:

- Marinus Link will be technically feasible for a capacity of 600 MW or 1200 MW (delivered in two 600 MW stages);
- there are routes that are feasible and likely to obtain environmental and planning approvals; and
- Marinus Link has a positive economic worth as large-scale retirement of coal-fired generation occurs, for either emission reduction or economic reasons. There are plausible circumstances where Marinus Link could be economically feasible from the mid-2020s.

Continued work will include further refinement of the initial assessment that Marinus Link is feasible, with updates in light of feedback received, new information and further analysis. It will also include a business case assessment on whether there is likely to be a commercial and financial case for Marinus Link, sufficient to warrant progressing the project to the Definition and Approvals phase.

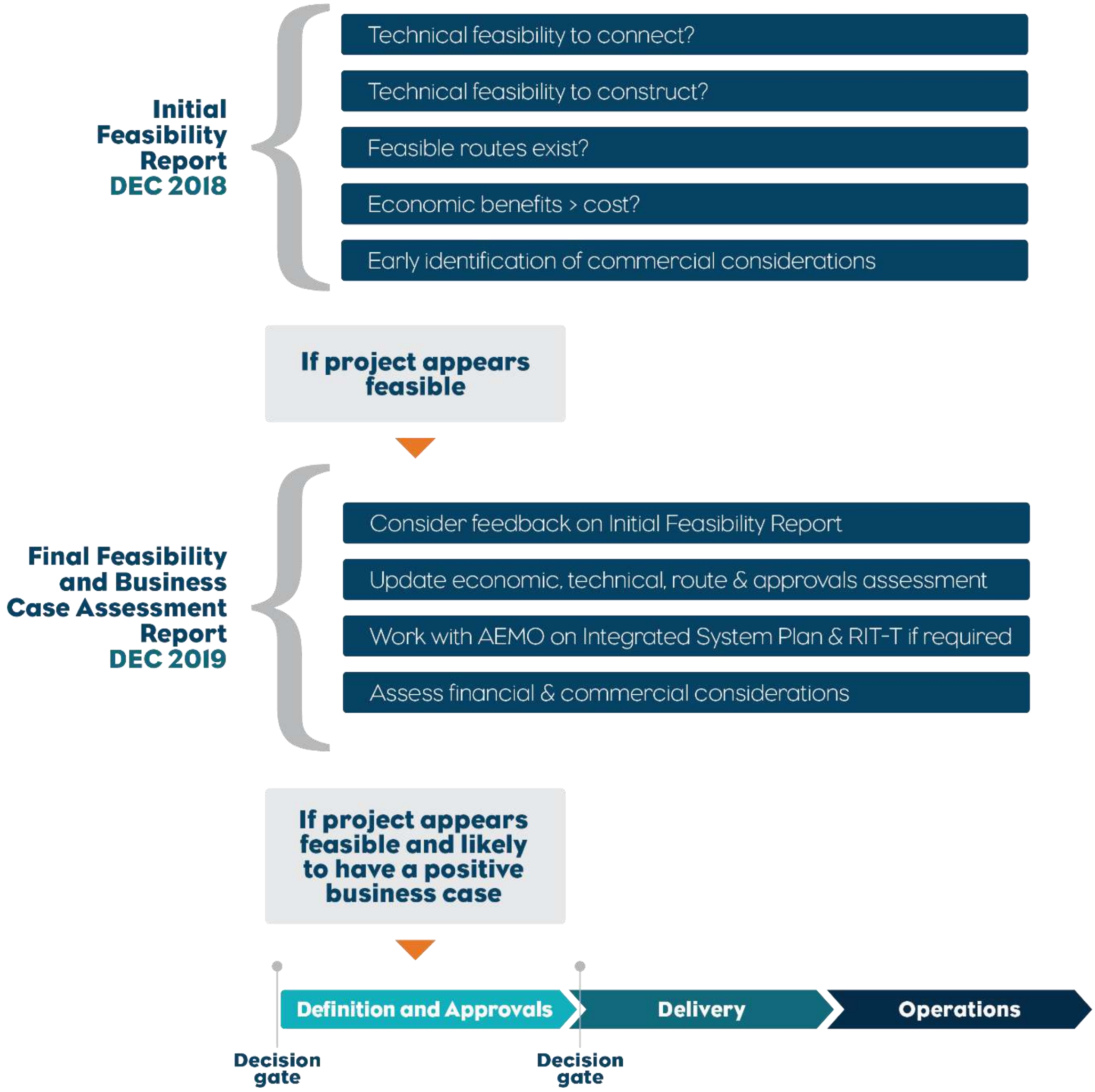
The Feasibility and Business Case Assessment activities will include:

- considering feedback on this Report;
- updating route option, economic, technical and approvals feasibility assessments;
- working with AEMO as the Victorian transmission planner and national planner, to progress further work on the ISP and Marinus Link RIT-T process (if required) – with a final assessment forecast by December 2019;
- assessing in greater detail the financial and commercial considerations to support the viability of Marinus Link, to secure an income stream, financing and appropriate customer pricing outcomes for Marinus Link; and
- summarising analysis in the Final Feasibility and Business Case Assessment Report, forecast to be released in December 2019.

Throughout the process, TasNetworks will continue to work with a range of stakeholders to understand arrangements that may affect project risks and timing.

Our approach is summarised in the flow chart displayed in Figure 6.

Figure 6 Flowchart of study approach



2.3. Full project scope

If at the completion of the Final Feasibility and Business Case Assessment Report, Marinus Link investment is assessed as likely to have a positive business case, the Project is expected to be progressed through the:

- Definition and Approvals;
- Delivery; and
- Operations phases.

To enter each phase, funding will need to be available and separate investment approvals will be required.

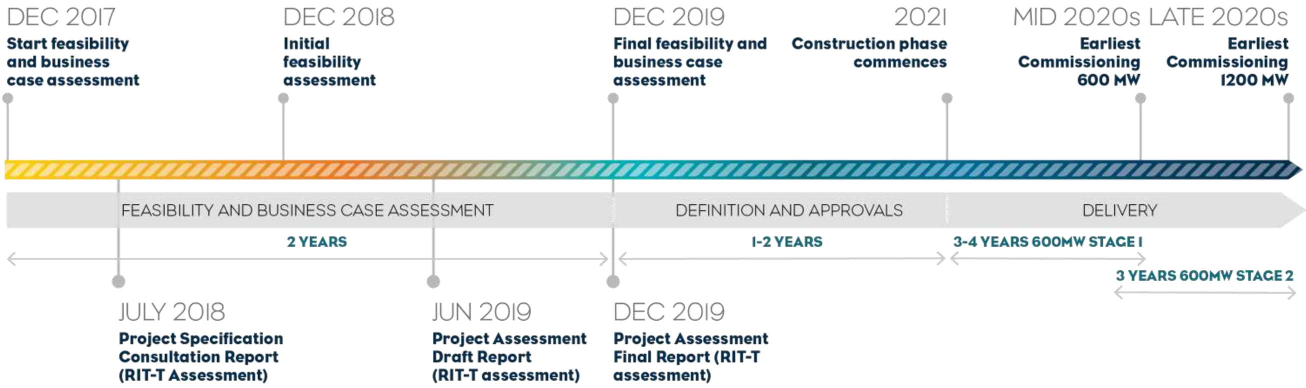
The detailed Definition and Approvals phase will include all activities required to support a final investment decision, which is the major business case to commit funds to deliver the project. The Definition and Approvals phase includes preliminary design of the cable, converter stations and required alternating current (**AC**) transmission upgrades (augmentations), achieving land use planning, environmental and heritage approvals, establishment of commercial arrangements with potential service providers and securing the required financing arrangements to deliver and operate Marinus Link. It involves securing sufficient revenue certainty to proceed. It also includes procurement of land and easement rights for the project.

Once the Definition and Approvals phase is complete, the updated assessment of costs and benefits will inform a final decision of whether or not to execute contracts and proceed with the investment.

In the event of a successful financial investment decision, the project will enter the Delivery phase, with final design and manufacture of equipment, construction and commissioning.

Figure 7 summarises key elements of the project delivery lifecycle, including indicative timelines for each phase, and the supporting regulatory investment reports that may be required. Once commissioned, Marinus Link would move into the Operations phase, with commercial operation and maintenance activities over an expected service life of at least 40 years.

Figure 7 Project delivery lifecycle



2.4. Feasibility Assessment Methodology

This section describes the economic, commercial and technical assessment approach that has been undertaken to inform this Report. These interrelated assessments have each contributed to and informed this overall assessment of the economic and technical feasibility of the project.

2.5. Technical assessment – power system integration

Is it technically feasible to connect a second interconnector to the Tasmanian and Victorian power systems and reliably and securely transfer electricity between these regions of the NEM?

This assessment considers the feasibility of connecting an additional Bass Strait interconnector with 600 MW or 1200 MW capacity in the context of Australia's evolving grid and the future technical requirements that will have to be met. This analysis considers the technical requirements of the Tasmanian and Victorian power systems including the existing Bass Strait interconnector. It assesses connection and operation of Marinus Link to ensure that the security and reliability of the power system is not compromised.

The continued growth of variable and inverter-connected generators – attributes of many renewable generation sources such as wind and solar generation – and retirement of coal-fired generators will impact on national electricity grid reliability. The assessment addresses technical considerations of the power system, focusing on dispatchable on-demand energy requirements, system strength, inertia and voltage control in the rapidly evolving NEM. It considers how Marinus Link may support improved power system outcomes.

The assessment considers the upgrades that may be required to the power system to support interconnector flows, and maintain power system security, including if the link trips off. These factors are also considered as part of the route selection feasibility assessment.

Given the rapidly changing energy market, and the changing nature of generation and load, the technical assessment includes development of real time simulator models to simulate connection of Marinus Link and a range of other potential projects to the Tasmanian and Victorian power systems. This work has commenced and will be completed in time for the Final Feasibility and Business Case Assessment Report.

2.6. Technical assessment – interconnector

Is it technically feasible to construct the link, given requirements of the cable and converter stations and supporting transmission connection and upgrades?

This assessment considers contemporary technology available for undersea interconnectors and assesses feasible options for connection between Tasmania and Victoria, with the new interconnector operating in parallel with Basslink.

It includes consideration of:

- interconnector capacity;
- high voltage alternating current (**HVAC**) or high voltage direct current (**HVDC**) selection;
- converter technology;
- cable insulation technology;
- interconnector topology configurations (cable and converter configurations);
- operation in parallel with Basslink; and
- manufacturer engagement.

These aspects are considered taking into account factors such as the environment in which the interconnector will be installed, undersea route length, connection to the Tasmanian and Victorian transmission networks and power system integration, staging opportunities, and risks.

It considers favourable technical configurations for Marinus Link, noting that technical analysis continues to refine and confirm a preferred configuration.

2.7. Route selection

Is it feasible to achieve external approvals for the project, taking into account likely routes and associated land use planning, environmental, heritage and social licence considerations?

This assessment identifies favourable route options – selecting options that meet technical project criteria and that are also expected to be feasible in achieving external approvals.

Options are shortlisted that are technically feasible and cost effective – in terms of construction of Marinus Link and its integration with the Tasmanian and Victorian power systems. Feasibility is also assessed across relevant land use planning, environment, heritage and broader social licence considerations associated with development corridors in Tasmania, Bass Strait and Victoria. This includes consideration of legislative obligations and the protection of social, economic, heritage, cultural and environmental values.

The shortlisted options are then subject to further assessment to identify the favourable routes. This includes further consideration of electrical connection, power system security and flexibility, facilitating renewable energy zones and future interconnection, and minimising cost and constraints.

2.8. Economic feasibility assessment

Is it feasible that Project Marinus would provide greater economic benefits than its costs under credible scenarios?

In considering whether the investment in Marinus Link will provide greater economic benefits than its costs, a range of relevant economic benefits and costs are considered. The modelling methodology and assumptions adopted to assess the future economic benefits and costs are described in general terms in this section and in more detail in Chapter 6 of this Report.

The assessment considers the capacity and broad timing of commissioning Marinus Link to maximise the net benefits of operation.

2.8.1. Economic assessment through cost-benefit analysis

Economic cost-benefit analysis is widely recognised as the most appropriate tool for evaluation of infrastructure investments[50]. It is a procedure to systematically measure the cost and benefits of each option over time from the perspective of the Australian community, evaluating the increase in social welfare over the economic life of the project. In economic terms, an increase in social welfare is made up of the following changes resulting from the project:

- the change in consumer surplus – put simply, the net cost or benefit to consumers;
- the change in producer surplus – the net cost or benefit to producers; and
- the change in externalities – the net impact on third parties[51].

Benefits and costs stretch over time, which needs to be explicitly incorporated in the analysis. To achieve this, benefits and costs are 'discounted' over time to arrive at a net present value (**NPV**). In this Report all costs and benefits have been discounted to the year 2025[52].

To understand whether Marinus Link is an economically efficient investment, this study considered whether, and in what circumstances, Marinus Link is likely to have a positive NPV. This was done by comparing NEM development outcomes with Marinus Link to NEM development outcomes achieved when Marinus Link is not constructed.

Economic cost-benefit analysis as it relates to an investment is different from the notion of its financeability. The former relates to whether the investment would be in the long-term interests of the Australian community; the latter relates to whether investors would be willing to fund the investment.

There are three core steps in assessing an infrastructure investment:

- problem or opportunity identification;
- options development; and
- economic appraisal

For Project Marinus the opportunity statement has been expressed as:

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[50] Infrastructure Australia, *Assessment Framework*, p.84
[51] The AER defines these terms as follows (AER Regulatory investment test for transmission application guidelines, 18 September 2017, p.13):
Consumer surplus: the difference between what consumers are willing to pay for electricity and the price they are required to pay.
Producer surplus: the difference between what electricity producers/transporters are paid for their services and the cost of providing those services.
Externalities: impacts on parties other than those who produce, transport and consume electricity in the market
[52] Costs and benefits were discounted to 2025 because this was the year that Marinus Link was assumed to be commissioned in the majority of studies undertaken, and therefore the year in which benefits of Marinus Link would begin to accrue. This approach is consistent with the RIT-T methodology.

The characteristics of customer demand, generation and storage resources vary significantly between Tasmania and the rest of the NEM. Increased interconnection capacity between Tasmania and the other NEM regions has the potential to realise a net economic benefit by capitalising on this diversity.

Two credible options have been considered:

- option 1: A 600 MW HVDC link, plus some of the associated alternating current transmission network upgrades and connection assets. Estimated cost approximately $1.3 - $1.7 billion[53]; and
- option 2: A 1200 MW HVDC link, plus some of the associated alternating current transmission network upgrades and connection assets. Estimated cost approximately $1.9 - $3.1 billion.

For either option the earliest commissioning date is 2025, with a 1200 MW link likely to be commissioned in two 600 MW stages at least 2 years apart.

The economic appraisal of Marinus Link will assess its estimated costs against the direct energy market benefits. It will also identify the wider economic benefits such a project could deliver. The energy market benefit categories considered in this assessment are:

- fuel, operations and maintenance cost savings;
- capital cost savings;
- reduction of unserved energy;
- resilience benefits, being a combination of the above in the event of an extended unplanned outage of Basslink;
- reduced ancillary services costs;
- avoided cost of future network investments that would be required without Marinus Link; and
- reduction of spilled renewable energy.

Work to consider three additional classes of benefits, power system security benefits, option value and competition benefits, will be undertaken in 2019. These three categories of benefits were thought to be of lesser value than the categories considered to date, and were therefore given lower priority. Inclusion of these benefits is likely to increase the overall benefit assessment.

2.8.2. RIT-T assessment process

The RIT-T[54] is the economic cost-benefit test used to determine whether a transmission investment should receive regulated revenues recovered from electricity consumers. Its objective is to protect consumers from

[53] Cost estimates exclude Tasmanian network upgrades from Palmerston to Sheffield, with this corridor identified by TasNetworks in the 2019-24 Revised Revenue Proposal as a contingent project which may be separately progressed as a result of increased renewable generation.

inefficient investments where costs outweigh benefits. The RIT-T is a form of economic cost-benefit analysis that has a narrower scope than the general economic cost benefit analysis set out above, in that it does not consider changes in externalities. The RIT-T framework is set out in the Rules, and tests for economic efficiency by determining whether major network investments would provide net positive benefits for all who produce, consume or transport electricity in NPV terms[55]. The RIT-T also has a prescribed consultation process to ensure interested parties can have their say. The test is currently under review (see section 6.6).

Simply put, the RIT-T aims to play the role of gate-keeper – so that electricity consumers only pay for investments that are economically efficient and optimal overall for the NEM.

In July 2018 TasNetworks released a Project Specification Consultation Report for a second Bass Strait interconnector, as the first step in the formal RIT-T process[56]. This reflects that Project Marinus is directed, among other things, to determining whether Marinus Link is likely to meet the requirements for approval by the AER to become a regulated interconnector. The economic feasibility assessment for Marinus Link has been conducted in accordance with both the framework set out in the Rules – and supporting AER RIT-T Application Guidelines – and the broader assessment framework published by Infrastructure Australia.

2.8.3. Assessment of energy market net benefits

The modelling used to assess the NEM-wide economic costs and benefits from the operation of a second Tasmanian interconnector has been a key input to this Report. The modelling approach is explained briefly in this section and in greater detail in Chapter 6.

The modelling methodology has been designed to quantify and compare longer-term changes in the generation mix and the transmission system, and the resulting energy market cost and benefit outcomes, with and without the second interconnector in operation, over a modelling horizon of 30 years. It assesses whether building Marinus Link, and the resulting energy solutions it unlocks, provides a better outcome than alternative solutions available to the NEM without Marinus Link.

Long-term, cost-based expansion modelling was used to assess, in the alternative states of the energy market being compared, the generation and transmission investments that would be required to maintain electricity supply at least cost to consumers over the modelling period. Modelling analysis was also undertaken to test the sensitivity of the modelling outcomes to changes in key parameters and assumptions about future energy market supply and demand conditions, relevant energy market policy settings,

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[54] Australian Energy Regulator, *Final - Regulatory investment test for transmission*, June 2010
[55] The study has based its analysis on the RIT-T and application guidelines (version 2). Australian Energy Regulator, *Final - Regulatory investment test for transmission*, June 2010; Australian Energy Regulator, *Regulatory investment test for transmission application guidelines*, September 2017
[56] TasNetworks, *Project Marinus Project Specification Consultation Report – Additional interconnection between Victoria and Tasmania*, July 2018.

implementation of other potentially competitive or complementary energy market investment proposals and changes to the timing and staging of a Marinus Link interconnector itself.

For the purposes of this Report, the modelling was based on a plausible scenario regarding longer-term conditions in the NEM, based mainly on AEMO's 'Neutral case' in the ISP. Under the parameters of that Neutral case, the 'neutral scenario' was specified to reflect existing and committed generation resources and the existing transmission network, with the addition of group 1 priority interconnection projects identified in the ISP. Marinus Link 600 MW and 1200 MW options were then added to the neutral scenario specification. This allowed modelling of the incremental costs and benefits that could be attributed to investment in Marinus Link, compared to the base case modelling outcomes.

2.8.4. Assessment of other impacts

Large infrastructure projects have impacts on individuals, landowners and communities affected by the project through its lifecycle, including construction activities. Some impacts will be positive, while others will be negative. The process to identify and select favourable routes aims to reduce negative impacts.

As part of our assessment, TasNetworks engaged EY to undertake an assessment of positive impacts to the community beyond energy market benefits. This includes benefits to regional communities in Tasmania and Victoria where interconnection investment will take place. Broader economic benefits also flow from the projects enabled by Marinus Link, such as Tasmanian pumped hydro storage investments, generation and network investment to support renewable energy zones. EY measures these benefits using 'contributions analysis' techniques to assess direct economic stimulus benefits and the broader economic stimulus benefits from projects forecast to be enabled by Marinus Link.

2.9. Commercial and financial analysis

A range of commercial considerations will impact feasibility of the project, including revenue, financing and pricing matters.

This Report focusses on the economic benefits and costs of a second Bass Strait interconnector, while the Final Feasibility and Business Case Assessment Report will include consideration of an appropriate business model to realise these benefits.

Interconnector costs, revenues and benefits form a significant input into analysis of the possible service models for Marinus Link. The economic modelling does not assume any particular service model, however, it does assume that the link is not artificially constrained for commercial reasons.

This Report outlines key elements of the ownership and service options, including project cost and delivery schedule.

There are a range of service options for the operation of Marinus Link. The interconnector could be developed as:

- a regulated transmission network service provider, supported by a RIT-T process (or an agreed alternative process);
- a market network service provider earning revenues on its market trading activities and/or provision of other services; or
- as a hybrid of the two.

As noted above, as part of assessing the regulated model, the RIT-T process has commenced. TasNetworks continues to engage with policy-makers, regulatory and market bodies on changes to NEM investment frameworks, to understand the commercial implications of the evolving NEM regulatory framework. This includes work to support the Energy Security Board's advice to the Council of Australian Governments Energy Council on a work program (including possible changes to the RIT-T) to convert the ISP into an actionable strategic plan.

The present RIT-T net benefit assessment process does not consider changes in consumer prices. However, this feasibility assessment has considered the indicative impact Marinus Link could have on final energy prices in Tasmania and the mainland NEM. While the project may deliver a positive net economic benefit across the whole NEM, the question of 'who pays' is highly relevant, particularly given the affordability concerns raised by customers and stakeholders. TasNetworks recognises this concern and notes project cost recovery options will be addressed in greater detail as part of the Final Feasibility and Business Case Assessment Report forecast to be released in December 2019.

A range of merchant interconnector models are in the early phases of investigation, including consideration of innovative commercial and operating models that may require Rule changes – including some hybrid models that combine merchant and regulated features that exist in international energy markets.

To understand arrangements that might support the financing of Marinus Link, initial analysis of possible commercial, financial and ownership options has been undertaken, building on the work carried out for the Tamblyn study.

Commercial and financial considerations will be addressed in greater detail as part of the Final Feasibility and Business Case Assessment, including various options for securing an income stream and financing Marinus Link. To this end, the Final Feasibility and Business Case Assessment will consider:

- Commercial models that refine how revenue can be derived from Marinus Link under regulated, merchant or hybrid models, exploring potential other service offerings of Marinus Link and ensuring appropriate return can be obtained. This will include more detailed analysis of existing merchant and hybrid interconnector models (in international markets, for example), and how they may be applied in the Australian regulatory framework.

- The risks and benefits of the likely ownership and funding structures for Marinus Link, including an outline of the ownership and funding models (both public and private) that would enable the successful development and operation of Marinus Link.
- More appropriate pricing frameworks that better allocate costs based on benefits accrued and ultimately seek fairer customer outcomes.
- Refinements to the project cost and delivery schedule supported by a greater level of project definition, technical information and delivery strategy.

Throughout the process, TasNetworks will continue to work with a range of stakeholders to understand potential arrangements – including funding arrangements – to support efficient and timely project outcomes.

2.10. Stakeholder and community engagement

The Feasibility and Business Case Assessment is supported by a Stakeholder and Community Engagement Strategy. The strategy outlines the project stakeholders and the principles and key approaches that guide engagement with them. It is supported by engagement activities that are coordinated, complementary and tailored to key stakeholder groups. The engagement activities will support the sharing of knowledge gained from Project Marinus.

3. Technical feasibility of the Project

This chapter details the technical feasibility assessment of Marinus Link. It encompasses interconnector technology selection and the integration requirements into the Tasmanian and Victorian power systems. Analysis is based on the assumption that Marinus Link and Basslink will operate concurrently.

Is it technically feasible to connect a second interconnector to the Tasmanian and Victorian power systems and reliably and securely transfer electricity between these regions of the NEM?

Is it technically feasible to construct the link, given requirements of the cable and converter stations and supporting transmission connection and upgrades?

Key messages

- Based on work done to date, Marinus Link will be technically feasible for a capacity of 600 MW or 1200 MW delivered in two 600 MW stages, across a range of technical parameters.
- Given the manufacturing and construction durations, the earliest a 600 MW link could be in service is the mid-2020s. A 1200 MW link delivered in two 600 MW stages could also see the first 600 MW commissioned by the mid-2020s and the full capacity two to three years later. This staging reflects design considerations, so that no more than 600 MW is lost in a credible contingency event, and also expected manufacturing and construction durations.
- Marinus Link can provide a range of technical benefits in an evolving future power system.
- Marinus Link can support power transfers securely and reliably between Tasmania and Victoria if the link configuration is designed to ensure the largest single contingency is less than 600 MW. To achieve this, a bi-pole or two symmetrical monopoles are the only viable configurations for a 1200 MW link.
- Given the relatively small Tasmanian power system, the final design and transfer capability of Marinus Link will need to carefully consider Tasmanian frequency and voltage control during system faults. These aspects will be studied in 2019 and may require a lower Marinus Link import capacity into Tasmania.
- High voltage direct current (**HVDC**) is the only suitable interconnector technology able to transfer the required power across Bass Strait. Voltage source converter (**VSC**) technology is the preferred option for the alternating current (**AC**) -to-direct current (**DC**) conversion required by Marinus Link.

In this chapter, the project's technical feasibility is covered in the following sections:

- 3.1 Technical requirements of the future power system – describes how changes in the way electricity is produced, transported and consumed influence the technical feasibility of this project.
- 3.2 Technological feasibility – details the feasibility of available technological options.
- 3.3 Next steps – outlines further technical studies to be carried out.

3.1. Technical requirements of the future power system

Marinus Link's technical feasibility has been assessed in the context of Australia's evolving grid and the future technical requirements that will have to be met. This analysis considers the technical requirements of the Tasmanian and Victorian power systems including the existing Bass Strait interconnector. It assesses connection and operation of Marinus Link to ensure that the security and reliability of the power system is not compromised. It considers how Marinus Link may support improved power system outcomes in a transforming NEM.

The assessment considers the upgrades that may be required to the power system to support interconnector flows, and maintain power system security, including if the link trips off. These factors are also considered as part of the route selection feasibility assessment.

The growth of variable and inverter-connected generators – attributes of many renewable generation sources such as wind and solar generation – and retirement of coal-fired generators has the potential to impact on national electricity grid supply reliability and power system security[57]. The assessment of Marinus Link technical feasibility therefore considers technical aspects of the power system associated with dispatchable on-demand energy requirements, system strength, inertia and voltage control in the rapidly evolving NEM, including the ways that Marinus Link may support better outcomes. Real time simulator models are being developed to inform assessment of more detailed Marinus Link technical requirements, with work underway.

3.1.1. Dispatchable on-demand energy requirements

Some renewable generators such as wind and solar are less dispatchable on-demand than traditional generators, such as coal-fired, hydro and gas-fired generators. This is due to the impact of weather variability on electricity generation. As such, a primary benefit of Marinus Link is to enable increases in the level of dispatchability of energy – that is, provision of on-demand energy – in the power system. Hydro generation has the advantage it can be brought on-line extremely quickly. The presence of Marinus Link would allow

[57] AEMO, *Power System Requirements Reference Paper*, March 2018, p.4

Tasmania's existing hydro generation, and new pumped hydro storage developed in Tasmania, to be utilised to bring a higher level of dispatchable on-demand energy to the NEM.

Marinus Link would connect geographically diverse areas. This allows variable generation to take advantage of geographical and weather diversity between Tasmania, Victoria and South Australia, meaning that variable energy sources will be available to meet demand across the NEM in larger volumes and over longer periods of time. For instance, there will be periods of variable generation output being high in Tasmania and low in Victoria, with the excess Tasmanian generation able to be transported via Marinus Link to support Victorian and NEM load. Conversely, excess solar or wind generation in Victoria could be transported to Tasmania. The modern interconnector technology means Marinus Link will be able to vary its power flow and quickly reverse direction without any interruptions to support the efficient supply of dispatchable on-demand energy. This is a benefit to the future power system.

3.1.2. System strength

Inverter-connected generation tends to reduce power system strength. In recognition of this developing issue, the AEMC released a rule to obligate TNSPs to maintain a certain level of system strength at certain nodes in the network. The technical specifications of Marinus Link will allow it to support the future power system and more inverter-connected generation by being able to operate with low system strength, and it may contribute to increased system strength. Marinus Link's ability to provide rapid voltage support will also assist in fault ride through of other inverter connected generation.

3.1.3. Inertia

The shift to a higher share of inverter-connected generation is also reducing the system inertia. Inertia is the system's innate ability to resist changes in system frequency following changes in generation or load. System frequency needs to be maintained within a prescribed tolerance level, and only have a certain rate of change, to support a secure power system. If inertia is too low for the change in generation or load, the frequency change may seriously affect power system security. With reduced system inertia, the future power system will need new mitigation measures to provide Frequency Control Ancillary Services (**FCAS**) to maintain power system security. Marinus Link will allow the transfer of FCAS between Tasmania and Victoria, contributing to better frequency control in both Tasmania and Victoria.

3.1.4. Voltage control

Rooftop photovoltaic can reduce the apparent operational demand, allowing it to lessen peak demand and further decrease the minimum demand seen in the network. AEMO's forecasts[58] are projecting the time of

[58] AEMO, *Electricity Forecasting Insights report*, 2017, available at http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/Electricity-Forecasting-Insights/2017-Electricity-Forecasting-Insights

minimum demand to move from overnight to midday by 2022 in Victoria, mostly driven by the increasing penetration of rooftop photovoltaic. With projected reductions in minimum demand, and resulting lightly loaded transmission lines, the occurrence of high network voltages are expected to worsen. These high network voltages create problems if the rating of equipment is exceeded.

Since the retirement of Hazelwood Power Station, the management of network voltage in the Victoria transmission system has been more difficult. One strategy for voltage control has involved short-term de-energisation of a 500 kiloVolt (**kV**) transmission line. Marinus Link may assist with voltage control within Victoria by acting as an additional load on the Victorian system when there is an excess of solar generation and by utilising the ability of Marinus Link converter station to produce or absorb reactive power.

3.1.5. Real time simulations

Given the rapidly changing energy market, and the changing nature of generation and load, the Marinus Link technical assessment includes development of models within a real time simulator. Using these power system models, TasNetworks can simulate connection of the potential Marinus Link and a range of other potential projects to the Tasmanian and Victorian power systems. The real time simulator allows simulation of a range of power system flows and contingencies to understand in detail how the power system would be expected to perform with Marinus Link in service. These simulations will help to identify the necessary technical requirements to support connection and operation of Marinus Link, to ensure that power system security is not compromised.

This work has commenced and will be completed in time for the Final Feasibility and Business Case Assessment Report.

3.2. Technological feasibility

This section covers the technological aspects of Marinus Link, with assessment provided in the following sections:

- 3.2.1 Interconnector capacity – identifying feasible transmission capacities for Marinus Link.
- 3.2.2 HVAC vs HVDC interconnection – selecting between an AC or DC transmission.
- 3.2.3 Converter technology– specifying a preferred AC-to-DC conversion technology.
- 3.2.4 Cable insulation technology – categorising preferred cable technologies for the options identified.
- 3.2.5 Interconnector topology configurations – nominating preferred transmission line layouts for the options considered.
- 3.2.6 Operations in parallel with Basslink – examines simultaneous operation of multiple Bass Strait interconnectors.
- 3.2.7 Manufacturer engagement – provides insights gained from discussions with suppliers of HVDC converter stations and cable manufacturers.

3.2.1. Interconnector capacity

The interconnector capacity refers to the amount of power that an interconnector can transmit. The rated capacity is the amount of power that can be transmitted continuously. An interconnector may transmit higher power, but for short periods of time only; this capacity is referred to as the short-term rating.

Selecting the most appropriate capacity for Marinus Link is a complex exercise. A lower capacity interconnector will be lower cost, but service capacity will be lower and relative cost per MW of capacity will be higher, due to lack of economies of scale. A higher capacity interconnector will have lower relative costs due to economies of scale, but the additional service capacity allowed may not justify the additional total costs and power system integration of the interconnector is more challenging.

Considering these characteristics, two capacity options are being assessed for Marinus Link: 600 MW and 1200 MW. The 600 MW capacity is similar to Basslink's capacity and is within the largest credible contingency that can be accommodated in the mainland NEM power system. The larger (1200 MW) capacity is comparable to the brown coal-fired Yallourn (1450 MW) and Loy Yang B (1000 MW) power stations in Victoria and the average Tasmanian customer load (of approximately 1200 MW). A 1200 MW capacity link can be designed so that the largest credible contingency associated with the interconnector is limited to loss of 600 MW. The Marinus Link capacity is in addition to the capacity available from Basslink.

3.2.1.1. Capacity selection

600 MW was chosen as the lower capacity option, reflecting that:

- economies of scale mean that there is little difference in total cost between a 600 MW interconnector and a smaller capacity interconnector; and
- 600 MW is the largest contingency the power system can handle, discussed further below.

600 MW approximately aligns with the maximum design capacity of Basslink. This gives confidence that Tasmania's existing System Protection Schemes and other advanced control schemes in place for Basslink can be modified or supplemented to accommodate an additional interconnector with similar capacity. Further, 600 MW is smaller than the largest generator contingency in mainland NEM regions. The contingency size in the event of a Marinus Link failure could consequently be handled by available ancillary services to manage system frequency and voltage. The capability to import power into Tasmania by Marinus Link may be lower than 600 MW under some circumstances.

Analysis to date indicates that a 600 MW link can be accommodated technically, and is a cost-effective scale for a smaller-capacity link.

A 1200 MW link was chosen as the upper capacity level, because the interconnector could be designed such that only half the capacity (or 600 MW) would be lost for any credible power system event. Loss of capacity above 600 MW on a credible contingency would be expected to increase system integration requirements and costs.

600 MW and 1200 MW represent the lower and upper limits of reasonable capacities. An intermediate capacity could be developed if it brings more net benefits. For example, if it is economic to develop capacity above 600 MW, but below 1200 MW.

Capacities above 1200 MW could be developed, provided the maximum credible contingency size was maintained at 600 MW. Early analysis suggested that there may not yet be an economic case for a link larger than 1200 MW, so this option has not been progressed further at this stage.

3.2.1.2. Preferred capacity

The preferred capacity for Marinus Link depends on the cost-benefit analysis results. Based on the current estimates of pumped hydro storage and other renewable energy development in Tasmania and the rest of the NEM, an option of developing Marinus Link in two 600 MW stages preserves the option of delivering either capacity link. This could allow either a 1200 MW interconnector to be developed in two planned stages, or for the additional capacity to be factored in and implemented over a more extended timeframe.

3.2.1.3. Feasibility of connecting into the Tasmania and Victorian power systems

The feasibility of connecting a 600 MW or 1200 MW interconnector into the Victorian and Tasmania transmission systems has been assessed in terms of the thermal capacity of the transmission network and voltage stability impacts. Technical connection considerations have been taken into account to identify the favourable routes between the Latrobe Valley in Victoria, and Sheffield or Burnie areas in north-west Tasmania, discussed further in Chapter 4. For connection into the Latrobe Valley area of Victoria no additional upgrades were identified to support the connection, however for connection into the north-west of Tasmania, upgrade of the existing transmission network will be required. This could include upgrade between Burnie and Sheffield to manage thermal capacity limitations and voltage stability constraints.

3.2.2. HVAC vs HVDC interconnection

There are two ways to transfer electricity in a power system: high voltage alternating current (**HVAC**) or HVDC. Higher voltages reduce system losses, and power systems are generally alternating current due to its relative ease of voltage transformation compared to DC.

However, over long distances, the efficiency of HVDC systems is higher than that of HVAC systems. This is particularly true where cable is used instead of overhead transmission lines. HVDC cables are lower cost than HVAC cables and do not require complex reactive power compensation. As Marinus Link would include

250-300 km of subsea cable in Bass Strait crossing, and underground and overhead HVDC land-based cable in Tasmania and Victoria, the only feasible option for Marinus Link is an HVDC interconnector.

3.2.3. Converter technology

Converters transform electricity between the HVDC of the interconnector and the HVAC power systems at either end. There are two main HVDC converter technologies available in the market. These are the Line Commutated Converter (**LCC**) and the VSC, which are presented in this section.

3.2.3.1. Line commutated converter

LCC technology, commonly known as HVDC Classic, has been used in subsea interconnectors and long-distance high-power transmission for more than 50 years. It is the technology employed on Basslink.

LCC technology has several limitations. Firstly, LCC technology requires a significant system strength environment in which to operate. Furthermore, changing power flow direction (e.g. changing flow direction from Victoria to Tasmania to Tasmania to Victoria) through an LCC requires a reversal period during which the interconnector cannot provide frequency control ancillary services.

The main advantages of LCC converter technology have typically been its higher power ratings, lower losses and faster DC fault recovery performance compared to VSC. However, these benefits are being eroded as VSC technology improves.

3.2.3.2. Voltage source converter

VSC is a newer technology and has only been developed for power transfer capacity greater than 500 MW in recent years. VSC technology is becoming more prevalent due to better technical performance and greater operational flexibility than LCC technology.

VSC technology can operate with low system strength, which is important in a power system with a growing share of inverter-connected generation. It is also easier to connect this technology to alternating current systems, as there are less harmonics and voltage transient issues. Power flow direction can be reversed instantaneously, allowing the continuous provision of frequency control ancillary services.

The main disadvantage of VSC technology is that it does not typically come with fast DC-side fault ride through capability, which affects its ability to be used with overhead HVDC transmission lines for land routes. Alternatively, full bridge VSC converters can be specified for fault ride through, allowing overhead DC transmission lines to be used. However, this specification could add approximately 25 per cent to converter costs.

In recent years, VSC HVDC solutions have standardised on modular multi-level converter technology with two converter valve designs: half bridge or full bridge. Half bridge configurations minimise the cost of point-to-point transmission but cannot quickly clear DC faults and so usually require HVDC transmission to be cabled. Full bridge configuration offers more robust performance and is suitable for clearing DC faults, allowing overhead HVDC transmission (which is lower cost than underground cable).

3.2.3.3. Preferred converter technology

Table 1 summarises the main differences between the two converter technologies.

Table 1 Comparison of converter technologies

Features	LCC	VSC
Cable voltage reversals required	Yes: voltage reversal requires higher cost DC cables	No: fixed DC voltage allows lower cost cross-linked polyethylene (**XLPE**) cables
Converter station land size	4 Ha	1 Ha
Power flow reversal	Voltage polarity reversal requires temporary separation of two AC systems	Immediate by smooth current reversal, no voltage stress on cable insulation
Reactive power control	Voltage limits and slow filter switching	Fully controllable
Frequency control ancillary services provision	Unavailable during power reversal	Continuous
Black-start capability	No	Yes
System strength requirements (minimum short circuit ratio)	Short circuit ratio of at least 2	Operated as current source – Short circuit ratio of 1.2 Operated as voltage source – can contribute fault current up to its continuous rating
Fault ride through	Yes	AC yes, (Fast) DC with 25 per cent additional converter cost
AC fault response	Poor: sensitive to inverter commutation failures	Good: can provide fast reactive support to network
Relative capital cost	1	1.3 times the cost of LCC technology
Maintenance costs	<1 per cent of converter capital cost	<0.5 per cent of converter capital cost

Tasmania's current level of system strength makes it unfeasible to host a second LCC interconnector of the magnitude proposed for Marinus Link. The system strength for the Latrobe Valley connection is forecast to be high until at least the 2040s. However once the last of the existing coal-fired generators in the Latrobe

Valley retires it is likely that the Victorian end of Marinus Link will also have low system strength. As such, the VSC technology with modular multi-level converter is proposed for Marinus Link due to its ability to:

- operate with lower system strength in Tasmania and a broader NEM future power system with increased inverter-connected renewable generation and less synchronous generation;
- support continuous power flow during power flow reversals;
- support continuous provision of frequency control ancillary services;
- provide substantial reactive support under alternating current system contingencies; and
- offer black start capability (the ability to re-start the power system after a blackout event).

3.2.4. Cable insulation technology

The cable supply, installation and protection represent a significant portion of the project costs and timing for Marinus Link (discussed further in Chapter 7). Cable technology selection is critical in terms of both performance and cost. Two HVDC cable technologies are available and have been considered for Marinus Link.

3.2.4.1. Mass impregnated non-draining cable

Mass impregnated non-draining (**MIND**) cable insulation consists of multilayer paper tape, impregnated with high viscosity oil-like compound (hydrocarbon compound).

The advantages of MIND cable technology are its track record and operational voltage availability. Available operational voltages are increasing, with Western Link in the UK becoming fully operational in October 2018 as the first subsea interconnector to use a direct current voltage level of 600 kV with MIND cables.

The disadvantages of MIND cable are its size, weight, low operating temperature (55 to 60°C), and cost compared with XLPE cable technology. The MIND cable can be used with both LCC and VSC HVDC systems and has a track-record going back 50 years.

3.2.4.2. Cross-linked polyethylene cable

While there are many HVAC XLPE cables in service with voltage ratings up to 500 kV, HVDC submarine XLPE cable technology is still undergoing rapid technological development. The technology's progress for HVDC was hindered due to low demand because of the unsuitability of XLPE cable for the voltage polarity reversal required with LCC HVDC converters. The increased application of VSC HVDC converters since the mid-2000s has created growing demand for HVDC XLPE cables, spurring its development.

The main advantages of the XLPE include higher operating temperature (75 to 90°C), and availability of pre-fabricated joints which lower the installation costs. Pre-fabricated joints provide particular cost benefit to the on-land cable sections of the interconnector. Underground cable sections are much shorter (~1 to 2 km only between joints) than subsea cable sections, and hence may have many joints for long on-land cable routes.

The disadvantages of the XLPE cable application with HVDC are the limited voltage range (up to 320 kV in operation as of today) and track record compared with MIND cables. For the same capacity, a lower voltage capability means a larger (and costlier) cable core is required.

XLPE cable can only be used with VSC converter technology, as it is unsuitable for LCC voltage polarity reversals. Technology developments may overcome this as new XLPE compounds offered have strength suitable for handling voltage polarity reversals.

3.2.4.3. Preferred cable technology

A summary of the main differences between the MIND and XLPE cable technologies is provided in Table 2.

Table 2 Comparison of cable technologies

Features	MIND	XLPE
Maximum nominal operating voltage	600 kV (already installed)	320 kV (already installed) 400 kV (in 2019) 525 kV (tested only)
Maximum operating temperature	55 to 60°C	75 to 90°C
Track-record	> 50 years	Approximately 20 years. Limited for voltages above 320 kV
Connects to converters	LCC and VSC	VSC

The VSC technology is the preferred option for Marinus Link, meaning both MIND and XLPE cables are technically feasible. The cable insulation technology selected for the project will be determined by a lifecycle cost assessment, and different technologies for sub-sea and land cable components may be chosen.

Operating voltage impacts directly on the economic link size, where a lower voltage cable requires a larger conductor cross-section for a given power transfer capacity, compared to a higher voltage cable. Hence, higher voltage cables are more suitable for larger capacity links.

Improvement in water tightness of submarine cable designs has offered a choice between use of traditional copper and aluminium conductors. Aluminium offers some price advantages, however the size of the aluminium conductor has to be increased to achieve a similar performance to copper conductor. This increase may have some impact on the logistics of submarine cable installation.

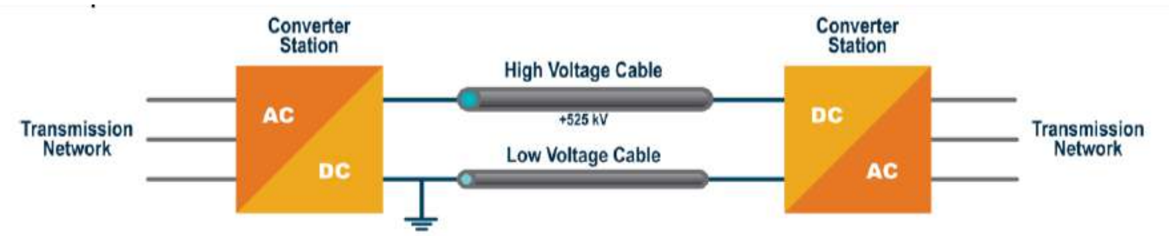
3.2.5. Interconnector topology configurations

Three different HVDC configuration topologies have been considered for Marinus Link. These include asymmetrical monopole, symmetrical monopole and bi-pole configurations, which are detailed in this section.

3.2.5.1. Asymmetrical monopole

Asymmetrical monopole configuration comprises of a single HVDC cable and converter station with a low voltage metallic return cable (presented in Figure 8). Basslink is an example of an asymmetrical monopole with metallic return. It is grounded at one terminal only to prevent flow of current through the ground.

Figure 8 Asymmetrical monopole (with low voltage metallic return cable) configuration



A single main system component fault in an asymmetrical monopole configuration system will result in the link's power transfer capacity reducing to zero. Marinus Link would therefore be limited to 600 MW in asymmetrical monopole configuration. An asymmetrical monopole link can be upgraded to bi-pole configuration with the installation of a second HVDC cable and accompanying converter stations. This would allow the interconnector to operate at 1200 MW capacity.

An asymmetrical monopole configuration tends to favour the use of a higher HVDC voltage. Application of 320 kV XLPE cables in asymmetrical monopole configuration results in high transmission losses therefore use of the higher voltage 400 kV XLPE or MIND cables would be preferred.

3.2.5.2. Symmetrical monopole

Symmetrical monopole configuration comprises of two HVDC cables with a single converter at each end (shown in Figure 9).

Figure 9 Symmetrical monopole configuration

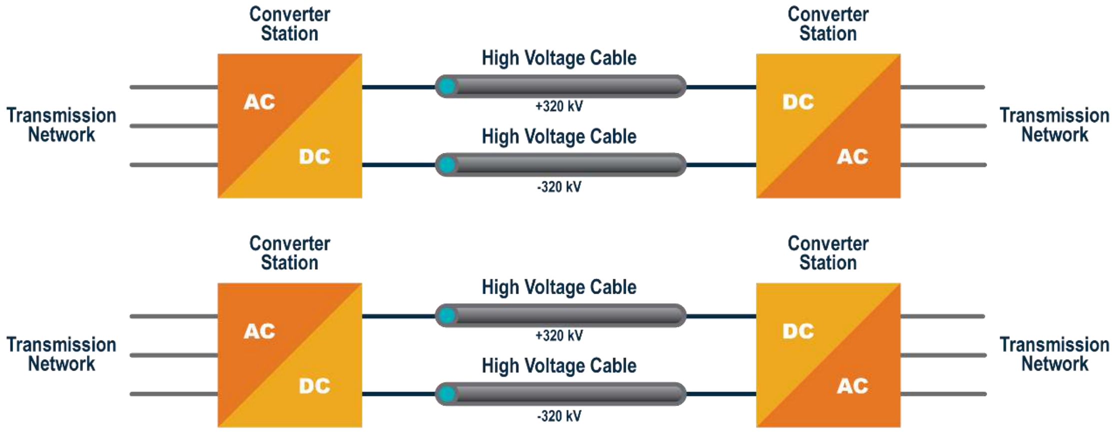
A symmetrical monopole that transfers the same power at the same DC current as an asymmetrical monopole will use two HVDC cables, each with 50 per cent of the high voltage (**HV**) rating of the single 100 per cent HV rated cable of the asymmetrical monopole. However, in practice due to the small number of available HVDC cable voltages (noted in Table 2), a symmetrical monopole will transfer power at lower DC currents and hence achieve lower transmission losses.

Converter cost is linearly proportional to the net DC voltage, since this determines the number of converter modules. Converter cost also increases, but non-linearly, with respect to DC current since only a few steps in semi-conductor current ratings are available. The lowest cost converter will be achieved when the full semi-conductor current rating is utilised at the lowest net DC voltage.

Cable costs are normally higher with symmetrical monopoles because HV cables are required, compared to one HV cable and one low voltage metallic return for the asymmetrical monopole. However, a 600 MW VSC converter, configured as symmetrical monopole can presently use either MIND or XLPE cables, whereas an asymmetrical monopole may be restricted to a MIND HV cable due to the higher voltage required.

Like an asymmetrical monopole, there is no redundancy as a fault on a single main component of a symmetrical monopole link will result in the entire link becoming unavailable. This would limit a Marinus Link symmetrical monopole to 600 MW. Symmetrical monopoles cannot be upgraded to bi-pole. Instead, to achieve 1200 MW capacity a second, parallel, symmetrical monopole would be needed (shown in Figure 10). The submarine cables for each monopole can be bundled, which reduces cable laying and physical protection costs.

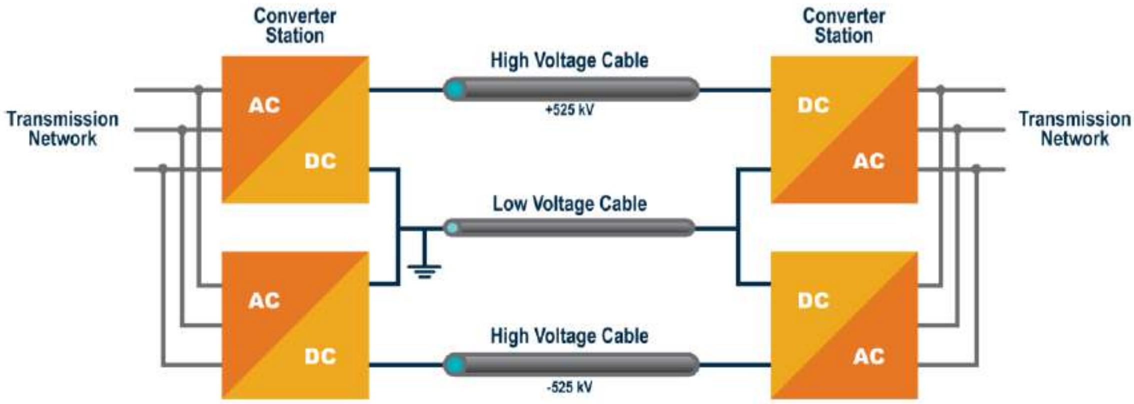
Figure 10 Two symmetrical monopole configuration for 1200 MW



3.2.5.3. Bi-pole

Bi-pole configuration comprises two HVDC cables and two converters at each end, together with a low voltage return cable (shown in Figure 11).

Figure 11 Bi-pole (with low voltage metallic return cable) configuration



The bi-pole configuration is conceptually the equivalent of two asymmetrical monopoles, but operating with a shared (single) current return path (the low voltage cable in Figure 11).

It has the advantage that the link can run at half capacity (i.e. operate as an asymmetrical monopole) if a fault occurs that removes one pole from service. This allows a bi-pole to operate at 1200 MW capacity, as a contingency will only interrupt 600 MW. 600 MW capacity will be available on the remaining in-service pole, acting as an asymmetrical monopole.

A bi-pole configuration is not economic for a smaller 600 MW link where the ability to operate at half power is not required. It could be economic for a 1200 MW link, developed in two 600 MW stages. Being equivalent to two asymmetrical monopoles, each asymmetrical monopole for a 1200 MW link would need to use higher voltages. A common earth return cable could be used.

Existing XLPE technology is not suitable for a 1200 MW bi-pole configuration as voltages of around 500 kV would be required, and there is presently no such XLPE cable with this voltage in service.

A bi-pole configuration provides efficiencies of scale and is lower cost for 1200 MW capacity than developing two symmetrical monopoles or a staged development of an asymmetrical monopole to a bi-pole.

To improve the reliability of bi-polar configuration, its three cables must be laid and protected separately (with minimum separation of at least 50 metres for undersea sections) so that damage or a fault of one cable does not affect availability of the remaining two cables required to support partial power transfer. A common mode of failure due to the interaction between bi-pole controls and protection is possible. However, such a failure is likely to be very rare and classified as a non-credible contingency.

3.2.5.4. Preferred configuration topology

A summary of the main differences between configuration topologies is presented in Table 3. The table presents comparisons between each configuration at both 600 MW and 1200 MW capacities. As detailed in Section 3.2.5.1 an asymmetrical monopole at 1200 MW capacity is effectively an upgrade of a 600 MW asymmetrical monopole to become a bi-pole, so no 1200 MW asymmetrical bi-pole is included.

The symmetrical monopole with 1200 MW capacity is achieved by two symmetrical monopoles. The relative costs presented in Table 3 are relative to the option of a 600 MW symmetrical monopole.

The actual cost comparison depends on the voltage-current trade-off for a given capacity, with higher currents giving higher cable costs, and higher voltages giving higher converter costs.

Table 3 Comparison of HVDC configuration topology

Features	Asymmetrical monopole	Symmetrical monopole		Bi-pole	
	600 MW	600 MW	1200 MW	600 MW	1200 MW
High voltage cables	1	2	4	2	2
Low voltage cables	1	0	0	1	1
Redundancy	No	No	Operate at half capacity	Operate at half capacity	Operate at half capacity
Relative cost	0.9	1	1.9	1.2	1.5

The preferred configuration topology for a 600 MW interconnector is the symmetrical monopole. It has lower losses than an asymmetrical monopole (due to the high net voltage across the cables) and can operate at lower cable voltages, which allows more mature technologies.

If the chosen capacity for Marinus Link is 1200 MW, either a bi-pole or two symmetrical monopoles could be used. Both options would be commissioned in two stages of 600 MW (for example, two to three years apart) and both options could defer the second stage if it was more economic to do so. The final configuration choice will depend on several factors including the forecast timing of the increase to 1200 MW (if staged), environmental impacts, available cable technology, risk and cost.

3.2.6. Operations in parallel with Basslink

There are many examples around the world where HVDC links successfully operate in parallel with other links. The proposed geographical separation between Basslink and Marinus Link will assist in reducing the potential for unwanted power system interactions, and impacts of contingencies affecting supporting assets. However, detailed technical studies are required to fully understand any potential technical interactions between the two links, with this analysis planned to be undertaken in 2019.

3.2.7. Manufacturer engagement

TasNetworks has consulted extensively with manufacturers of HVDC converter stations and cables to understand the cost and performance of current technologies and expected trends in future performance. The focus of discussions with suppliers of HVDC converters has been the performance under very high penetration of inverter connected energy sources and the performance of the converters during, and following, transmission system faults. All suppliers are aware of the impact of increasing penetration of inverter-connected generation on system performance and they are addressing these challenges with various advanced control modes for the converters.

3.3. Next steps

Following this Report, the favoured route will be identified and more detailed dynamic simulation studies will be conducted. This will include the use of real time simulations to identify specific technical issues relating to Marinus Link's integration into the Tasmanian power system and its control interactions with other new inverter-connected generation and Basslink. Analysis will also be undertaken to consider interaction with the larger Victorian power system, recognising that this is likely to be more straightforward from a technical perspective. Future work will confirm the technical feasibility of Marinus Link, the requirements of its operation and any operational limits, and help dictate the technology and configuration required of the interconnector.

There are several key objectives for the next stage of work:

- Identify the technical envelope of Marinus Link exports and imports with varying renewable generation;
- Develop a detailed understanding of the cost difference, environmental and system impacts between bi-pole and two symmetrical monopole configurations for a 1200 MW link;
- Determine the preferred HVDC configuration, voltage level and cable technology of Marinus Link;
- Identify the ability of Marinus Link and new renewable generation to ride through system faults under low system strength operational scenarios;
- Identify required extra dynamic support to satisfy adequate voltage recovery after system contingencies;
- Identify required frequency control features of Marinus Link;

- Identify the interaction between Marinus Link, new inverter-connected generation and existing wind farm controls;
- Develop the HVDC control specification for Project Marinus that addresses an identified operational envelope (such as the ability to achieve Virtual Synchronous Generator mode);
- Evaluate the impact of pumped hydro storage technology (synchronous or variable speed) in system performance, including the trade-off between increasing system inertia and strength versus improved load control and fast frequency response; and
- Evaluate Marinus Link's black start capability for restoring power.

4. Route selection

This chapter details the assessment of feasible routes for Marinus Link and how the favourable routes for Marinus Link were identified.

Is it feasible to achieve external approvals for the project, taking into account likely routes and associated land use planning, environmental, heritage and social licence considerations?

Key messages

There are interconnector routes that are feasible and likely to obtain environmental and planning approvals.

The favourable routes for a 600 MW to 1200 MW Marinus Link connect a converter station in Victoria's Latrobe Valley by HVDC cable to a converter station in the Sheffield or Burnie area in the north-west of Tasmania.

Analysis is underway to identify the favoured route, with routes identified that have favourable technical and economic characteristics and that are likely to achieve environment, planning and cultural heritage approvals, land access, consents and acquisition.

Identification of the favoured route is expected in the first quarter of 2019.

It is prudent to secure land access rights for potential interconnector routes in the short term before the corridors become constrained.

Figure 12 Indicative routes for Marinus Link

In this chapter, route selection is covered in sections:

- 4.1 Potential route options – describes how the range of potential route options were identified.
- 4.2 Shortlisting of potential options – details how potential options were shortlisted.
- 4.3 Favourable routes – outlines the characteristics of favourable routes.
- 4.4 Corridor protection – highlights the strategic value of protecting interconnector corridors.
- 4.5 Next steps – notes activity to support selection of a favoured route and the environment, planning and heritage approvals process.

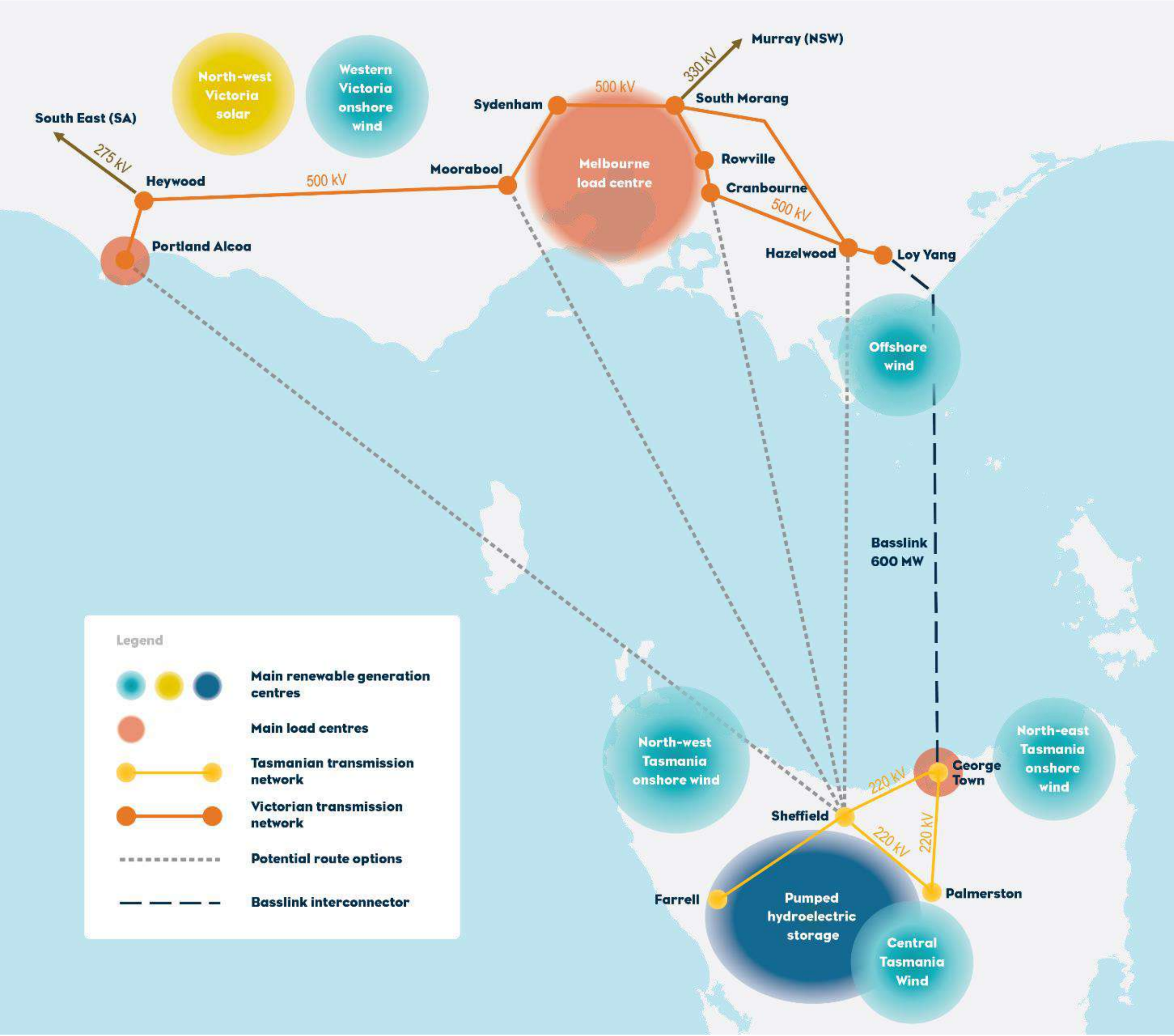
4.1. Potential route options

TasNetworks conducted an options analysis of potential routes for Marinus Link between a range of connection points in the Tasmanian and Victorian electricity grids. Points were considered that could deliver dispatchable on-demand energy capacity from Tasmania to meet Victorian load, and also deliver excess variable renewable energy from Victoria to Tasmania.

For strategic context, Figure 13 below shows a concept diagram of the Tasmanian and Victorian transmission networks, including the potential connections between the Victorian and Tasmanian network backbones, and major demand and potential renewable energy developments. The energy development areas are aligned to renewable energy zones identified by AEMO in its 2018 ISP. As illustrated in Figure 13, the grid backbone in northern Tasmania is a double-circuit 220 kV network formed by Farrell, Sheffield, George Town and Palmerston substations. The strongest existing connection points in the Tasmanian network in proximity to the Tasmanian north coast are Sheffield and George Town.

In Victoria, the grid backbone is the 500 kV network comprising Loy Yang, Hazelwood, Cranbourne, Rowville, South Morang, Keilor, Sydenham, Moorabool, Heywood and Portland Alcoa 500 kV substations. The strongest existing connection points in the Victorian network in proximity to the Victorian coast are Portland, Moorabool, Cranbourne, Hazelwood and Loy Yang.

Figure 13 Connecting Tasmanian and Victorian transmission networks – conceptual overview including load centres and renewable energy zones



Potential route options across Bass Strait were identified over a large geographical area allowing for both reasonable route lengths and the opportunity to connect to existing electricity infrastructure. They were identified to take advantage of strong electrical nodes in the Tasmanian and Victorian transmission networks. The electrical strength of the existing nodes was analysed, to understand their ability to support energy flows from the new interconnector. When considering route options under the strategic assessment, the need to support the evolution of the power system over the life of Marinus Link was also considered.

Areas covered by the route options analysis included the Tasmanian north coast, and the Victorian coast from Portland (in the west) to the Loy Yang area (in the east). Routes were identified using a substantial amount of data, criteria analysis and previous interconnector studies.

4.2. Shortlisting of potential routes

Desktop reviews of all potential routes were conducted, reviewing a large amount of data relating to environmental, social and cultural heritage values, land use planning, land tenure, and economic, engineering and power system integration factors.

These desktop reviews were complemented by site visits and further assessment of routes to confirm their feasibility.

The number of initial route options were reduced based on identified constraints, such as:

- significant distance and cost;
- environmental and social impacts such as protected areas, heritage, prime agricultural land, current and future rural and urban developments;
- significant constructability and operability issues, for example, subsea cable exposure to high velocity currents, location of other infrastructure and geology; and
- impacts on power system security.

A route option close to Basslink was not shortlisted in this Report, given the significant benefits of achieving geographical and power system diversity for a second Bass Strait interconnector. However, the Basslink corridor remains an option to be considered for subsequent interconnectors.

High level analysis was undertaken of a route via potential offshore wind resources in Victoria. This analysis found the option to be uneconomic due to the significant additional HVDC route length and the significant costs of connecting offshore wind to HVDC, compared to alternatives.

Based on the analysis, favourable routes connecting the Latrobe Valley region of eastern Victoria and the Burnie or Sheffield areas of north-west Tasmania have been identified, with work continuing to identify the favoured route. Details of shortlisted routes have not been included in this report due to commercial sensitivities and TasNetworks' intent to engage with landowners and communities ahead of public release of the favoured route. Identification of the favoured route is expected in the first quarter of 2019.

The sections below summarise some key considerations for the favourable routes.

4.2.1. Consideration of cost

To arrive at the favourable routes, a number of key cost implications were considered including: the overall HVDC route length, the scope of required network upgrades and land values. High level cost estimates were used to differentiate between route options.

4.2.2. Environmental and social criteria

Each shortlisted route was assessed against environmental and social impact criteria including: landholdings, proximity to houses, high quality agricultural land, native vegetation, threatened ecological communities, threatened species, sensitive coastal ecosystems, marine archaeology (including shipwrecks), fisheries and potential contamination. No fatal flaws have been identified in relation to any of the favourable routes in assessments to date, and the identified issues are considered manageable through route refinement, construction methods and timing, and native vegetation offsets.

4.2.3. Design and constructability considerations

The shortlisted routes were assessed against design and constructability considerations including: overall length, cost, availability of land for converter stations, the number and nature of landholdings in the proposed corridor, onshore constructability, offshore constructability, third-party interference, subsea infrastructure crossings, subsea cable exposure to high velocity currents, geology, proximity to other infrastructure, security and redundancy, and capacity to facilitate connection to renewable generation.

4.2.4. Network considerations

The shortlisted routes were assessed against a number of network considerations. An important consideration is the evolving generation mix in the NEM, and potential location of new generation and storage resources. TasNetworks therefore considered potential future renewable energy developments, and changes in generation mix in Tasmania and Victoria in the route selection process.

AEMO's ISP identifies several renewable energy zones (see Figure 14 below), with wind energy and utility scale solar generation being developed primarily in the west and north-west of Victoria, and wind and pumped hydro in the north of Tasmania. There is also a range of renewable energy projects proposed in the east of Victoria, including offshore wind. AEMO's ISP also projected significant retirement of coal-fired generation over the next 20 years in accordance with each plant's technical life.

Figure 14 Renewable energy zones in proximity to Tasmania and Victoria as identified in AEMO's 2018 ISP[59]

In order to realise the full potential of the developed renewable energy projects, the interconnector location should consider the transmission congestion and losses associated with moving electricity from existing and new generator sites to customer load points, and how congestion and losses can be cost-effectively managed.

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[59] AEMO, *Interactive Map*, available at: http://www.aemo.com.au/aemo/apps/visualisations/map.html (viewed 27 September 2018)

Another major factor affecting route selection is Hydro Tasmania's Battery of the Nation analysis which identifies a range of Tasmanian renewable energy and storage proposals including better utilisation of existing hydro assets, redevelopment of existing hydro assets, and development of cost-competitive wind and pumped hydro storage. A map of the shortlisted potential pumped hydro storage sites identified by Hydro Tasmania is shown in Figure 15[60].

Figure 15 Pumped hydro storage potential in Tasmania

Battery of the Nation analysis to date has identified significant Tasmanian energy generation and storage potential over the longer term, with up to 3500 MW of pumped hydro storage, 6500 MW of wind generation and 3800 MW of interconnection capacity with mainland Australia[61].

Tasmania has significant wind development potential, with two committed Tasmanian wind projects: Cattle Hill (144 MW) connecting to Waddamana Substation in the southern network and Granville Harbour (112 MW) connecting to Farrell Substation on the West Coast. With Marinus Link, economic modelling indicates that further renewable generation and pumped hydro storage will be developed in Tasmania. As noted in its recent public submission to the Project Specification Consultation Report, UPC Renewables is investigating over 1,000 MW of wind energy projects at Robbins Island and Jims Plain in north-west Tasmania. The ultimate scale of these developments is uncertain and will be influenced, in part, by resolution of environmental issues and securing overall project approval. There are a number of other developers progressing smaller scale renewable energy projects across Tasmania.

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[60] Hydro Tasmania, *Investigating Tasmania's pumped hydro storage potential*, available at: https://www.hydro.com.au/clean-energy/battery-of-the-nation (viewed 27 September 2018)
[61] Hydro Tasmania, *Battery of the Nation – Analysis of the future National Electricity Market, Appendix D. Build out scenarios*, p.134.

Victoria has a large number of renewable energy projects either existing, under construction, permitted or with potential. Routes for Marinus Link were considered in the context of minimising congestion on the Victorian network with projected Victorian renewables and Marinus Link taken together.

In considering the shortlisted route options, analysis was undertaken to consider the network configuration and upgrades required to support each option in the context of broader developments. Sites in north-west Tasmania, including in the Burnie and Sheffield areas, and in the Latrobe Valley area of eastern Victoria have been identified as favourable locations for new converter stations and connection to the transmission networks. This reflects technical analysis of the transmission network's ability to host an interconnector of 600 MW or 1200 MW and broader network planning and operation considerations.

Figure 16 illustrates a stylised version of the Tasmanian transmission network, including potential investment requirements to support Marinus Link. The Tasmanian transmission network would need upgrade to support either a 600 MW or 1200 MW link – including upgrade of the existing Sheffield to Burnie transmission line if the converter station is in the Burnie area. This upgrade would also strengthen the Tasmanian network to support increased renewable energy and storage potential. Upgrade between Palmerston and Sheffield may also be required to efficiently support renewable energy development in Tasmania with or without Marinus Link.

Figure 16 Possible route network configuration (Tasmania)

Consideration of Victorian options has included preliminary discussions with Victorian TNSP AusNet Services to consider potential impacts of, and synergies with, Marinus Link. As part of its recent public submission to the Project Specification Consultation Report[62] AusNet Services reaffirmed that

[62] AusNet Services, *Project Marinus PSCR Feedback,* 26 October 2018, https://projectmarinus.tasnetworks.com.au/assets/RIT-T-submissions/RIT-T%20PSCR%20submission%20-%20AusNet%2026%20October%202018.pdf

interconnection from Tasmania to the East Coast of Victoria may be efficient due to the characteristics of the existing Victorian network design, and the possibility of realising interconnection benefits without requiring deeper network upgrade in the Latrobe Valley area. Recent retirement of the 1600 MW Hazelwood Power Station means that capacity is available on the transmission network east of Melbourne. The 500 kV transmission lines to Melbourne are expected to become even less loaded over time as coal-fired generation continues to retire.

AEMO assessed the impact of a 600 MW Marinus Link on the Victorian shared network, considering a range of connection points in its 2018 Victorian Annual Planning Report (**VAPR**). The VAPR noted[63] that there would be no material impact on the local network if Marinus Link is connected to either Loy Yang 500 kV or Cranbourne 220 kV or 500 kV. The same conclusions would be expected to apply for connection to substations that are electrically close.

Figure 17 illustrates the existing transmission network configuration in Victoria including potential Marinus Link connection.

[63] AEMO, *Victorian Annual Planning Report*, 2018, p.40

Figure 17 Victorian network with Marinus Link (Victoria)

4.3. Favourable routes

Routes exist that are feasible for Marinus Link, considering:

- relative proximity to existing and potential energy generation and storage sites;
- delivering energy efficiently to load centres in Victoria and Tasmania;
- geographic separation from the current Bass Strait interconnector and supporting transmission network, supporting power system security;
- indications that environmental and social impacts can be appropriately avoided or mitigated to an acceptable level and that environment, land use planning, and cultural heritage approvals can be achieved;
- potential to achieve easement and land corridor access;
- cost; and
- potential for further interconnection, if warranted in the future.

Final analysis is underway, with identification of the favoured route expected in the first quarter of 2019. Indicative favourable route options between the Latrobe Valley and north-west Tasmania are illustrated in Figure 18 below.

Figure 18 Indicative routes for Marinus Link

4.4. Preserving corridors

Many of the identified corridors for Marinus Link are becoming constrained by urban, rural residential and rural living developments. Accordingly, future interconnectors are expected to become more difficult and costly to construct. Analysis has highlighted the prudence of securing corridors for Marinus Link in the short term, including land and easements, to support interconnection and reduce overall project costs.

Infrastructure Australia has undertaken analysis highlighting the economic benefits of securing infrastructure corridors sooner in the project development process, rather than later[64].

4.5. Next steps

A more detailed investigation of the favourable routes will now be undertaken, to support selection of the favoured route. This includes studies of both the terrestrial and marine environments to confirm route feasibility. Engagement with landowners and communities will occur ahead of public release of the favoured route, including native title holders, traditional owners and Aboriginal communities in the relevant areas. System integration studies, and more detailed network and asset configuration design will be undertaken to inform the environment and planning approvals process, discussed further in Chapter 3.

[64] Infrastructure Australia, *Corridor Protection: Planning and investing for the long term*, July 2017

5. Environmental and planning approvals and land assembly

This chapter identifies the environmental and planning approval requirements expected for Marinus Link, and key land assembly requirements[65] to obtain tenure for the required land.

Delivering Marinus Link will require a range of environmental, planning and heritage approvals from the Tasmanian, Victorian and Commonwealth Governments. Under each jurisdiction different assessment and approval pathways could be applied to the project.

TasNetworks is considering these options and will seek an approval pathway in consultation with the three governments that:

- applies an appropriate level of assessment to a project of this nature;
- includes transparent stakeholder engagement;
- satisfies the legislative requirements of all three jurisdictions; and
- facilitates efficient and timely assessment of the project.

5.1. Likely approval requirements

Marinus Link would extend across the jurisdictions of the Tasmanian, Victorian and Commonwealth Governments. This Report focuses on the key approvals needed; that is, approvals that are on the project critical path. Gaining key approvals for the project is a critical activity in the Definition and Approvals phase, required to proceed to the Delivery phase of the project. Obtaining environmental and planning approvals is expected to take 18 to 24 months.

Marinus Link crosses three jurisdictions, so a key challenge will be coordinating assessment and approvals across jurisdictions. Table 4 below outlines, at high level, the key infrastructure components across each jurisdiction and the range of legislation that would need to be considered as part of the assessment and approvals process. Discussions with each jurisdiction indicate a willingness to work together in designing a shared framework for determining the scope of assessment and process for approvals, including stakeholder engagement. This is to ensure that legislative requirements are met, relevant impacts are appropriately assessed, and information is provided to the community in a way that is transparent, coordinated and easily understood.

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[65] Land assembly requirements are all of the land tenure and consents required to enter and use land for the construction and operation of Marinus Link.

Table 4 Range of assessment and approvals legislation in each jurisdiction

Jurisdiction	Scope of project within jurisdiction	Assessment and approval considerations
Tasmania	• Upgrade to existing and new transmission lines • Underground and overhead land cable • New converter station • Upgrade to existing and new switchyards • Coastal crossing • Subsea cable	Project of State Significance under *State Policies and Project Act 1993* (Tas); or Project of Regional Significance under *Land Use Planning and Approvals Act 1993* (Tas); or Major Infrastructure Development Approval under *Major Infrastructure Development Approvals Act 1999* (Tas); and Aboriginal cultural heritage agreements.
Victoria	• New transmission lines • Underground and overhead land cable • New converter station • Modification to existing switchyard • Coastal crossing • Subsea cable	Environment Effects Statement under the *Environment Effects Act 1978* (Vic); and/or Planning permit or Planning Scheme Amendment under the *Planning and Environment Act 1989* (Vic); and Consent under the *Marine and Coastal Management Act 2018* (Vic); and Cultural Heritage Management Plan under the *Aboriginal Heritage Act 2006* (Vic).
Commonwealth	• Upgrade to existing and new transmission lines • Underground and overhead land cable • New converter station • Modification to existing switchyard • Coastal crossing • Subsea cable	Public Environment Report; or Environmental Impact Statement under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth).

5.2. Land assembly

When the final detailed route is confirmed, TasNetworks will identify any requirements to comply with native title and traditional ownership laws in each jurisdiction, as well as confirming the Crown land access requirements in each jurisdiction.

TasNetworks is continuing to develop its plan for consultation with other landowners affected by the favoured route and develop its land assembly strategy for obtaining easements and other land interests necessary to deliver the project.

5.3. Next steps

Work will continue with the Tasmanian, Victorian and Commonwealth jurisdictions, to confirm assessment and approval requirements and explore opportunities to streamline approval processes across the three jurisdictions.

Baseline environmental assessments will also be progressed, to gather information required to support the approvals process, including to:

- document the current environmental values to identify ways to avoid and mitigate impacts;
- inform the conceptual design of the project; and
- support potential planning, environment and heritage referral requirements to approvals agencies in Tasmania, Victoria and Commonwealth.

Work will also continue to identify native title and traditional owner engagement and approvals required, and to finalise the landowner engagement and land assembly strategy for the final proposed route.

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6. Economic feasibility of the Project

This chapter summarises the economic assessment of Marinus Link. The assessment includes an evaluation of the identified benefits and costs associated with a second interconnector.

Key messages

Is it feasible that Project Marinus would provide greater economic benefits than its costs under credible scenarios?

- Marinus Link would be a strategic interconnection investment providing NEM-wide economic benefits. Marinus Link provides value by enabling substitution of lower cost Tasmanian hydro generation, pumped hydro storage and competitive renewable resources for higher cost thermal and renewable generation in mainland regions of the NEM. It enables cost-effective dispatchable on-demand generation and a range of power system stability services to firm and support the NEM's transition to renewable energy resources.
- The economic feasibility of Marinus Link is dependent on assumptions made about future developments in the NEM and timing of Marinus Link being in service, with a range of possible outcomes.
- AEMO's 2018 ISP considered Marinus Link as an investment in the mid-2030s, and worth further investigation to determine optimal timing. This Initial Feasibility Report has focused on understanding the circumstances where the link would be beneficial from the 2020s.
- The largest single influencing factor in the economic viability and timing of Marinus Link is the trajectory of coal-fired generation retirement in the NEM. A key value driver for Marinus Link is its ability to supply on-demand renewable power to the NEM as large-scale retirement of coal-fired generation occurs. There are plausible circumstances where Marinus Link could be economically feasible from the mid-2020s.
- The benefits of Marinus Link are likely to be greater than costs when approximately 7000 MW of the NEM's present coal-fired generation capacity retires, which could occur from the mid-2020s (with early retirement) to the mid-2030s (with retirement at the end of design life). Coal-fired generators could retire ahead of design life for emissions reduction or economic reasons.
- Most energy market benefits would be realised in mainland NEM regions, with Marinus Link supporting lower cost energy outcomes to meet mainland NEM customer demand.
- Marinus Link would unlock broader economic value in regional communities in Tasmania and Victoria. In Victoria construction and operation of Marinus Link is estimated to provide economic stimulus of

over $1 billion, with more than 900 direct and indirect jobs during peak construction. In Tasmania, Marinus Link would provide economic stimulus directly, and also from the new investment in renewable energy projects that it enables. In Tasmania construction and operation of Marinus Link is estimated to provide economic stimulus of over $600 million, with more than 500 direct and indirect jobs during peak construction and thousands more in related projects.

- Given the long lead-time to implement Marinus Link, and potentially significant benefits, it is prudent to progress the project as a risk mitigation measure for a transforming NEM.

This chapter includes the following sections:

- 6.1 Methodology – provides an overview of the two aspects of economic benefits considered: NEM benefits and wider economic benefits.
- 6.2 Assessing economic worth to the NEM – covers the process used in assessing the costs and benefits of this project that relate to the NEM.
- 6.3 NEM economic worth outcomes – details the results of this economic assessment.
- 6.4 Wider economic benefits – discusses additional benefits to the broader community which have value, but are not included in the economic worth calculation.
- 6.5 Role for governments – discusses the reasons governments may wish to contribute funding to Marinus Link.
- 6.6 Regulatory framework review – outlines the changes that may occur to the investment framework for interconnectors.
- 6.7 Summary of economic analysis findings – discusses the results and key findings of this Report.
- 6.8 Next steps – outlines further work to be undertaken in the Final Feasibility and Business Case Assessment.

6.1. Methodology

The focus of the economic assessment is to analyse the potential benefits to the NEM from the construction and operation of Marinus Link, and to identify the circumstances in which the benefits are likely to outweigh the costs involved. The assessment also considers the broader economic benefits of Marinus Link to the Victorian and Tasmanian economies.

The assessment of economic worth of Marinus Link is discussed in Sections 6.2 and 6.3 below. The economic worth is the present value of the economic benefits resulting from Marinus Link, minus the present value of its costs, expressed in terms of its NPV[66]. In this part of the assessment, the economic worth of Marinus Link considers only the cost and benefits which accrue within the NEM, and these costs and benefits could be considered under the RIT-T assessment framework[67].

The wider economic benefits, which have value to society but are not included in the calculation of economic worth, are discussed in Section 6.4.

The economic assessment presented in Sections 6.2 and 6.3 differs in one significant respect from the RIT-T. The RIT-T requires that cost-benefit analyses be undertaken considering a number of scenarios, and the results from the scenarios be appropriately weighted to determine an overall net market benefit. The analysis in Sections 6.2 and 6.3 did not consider different scenarios; it considered only one scenario, from which a number of sensitivity analyses were undertaken. While the purpose of the RIT-T (as currently configured) is to evaluate whether there is an overall positive net market benefit, the purpose of the analysis presented in this chapter is to determine whether plausible circumstances may exist in which the benefits of Marinus Link outweigh its total costs, and if so, the economic worth in such circumstances[68].

In its 2018 ISP, AEMO considered Marinus Link as an investment in the mid-2030s, noting that further investigation is required to determine optimal timing. The economic analysis in this chapter has primarily examined whether an earlier commissioning date could be economically justified, and if so under what circumstances. The assessment therefore took 2025 as its starting point for a plausible early commissioning date of Marinus Link, with the majority of analysis considering Marinus Link commissioning from this time. Given the ISP results, less detailed analysis was conducted based on commissioning in the 2030s. TasNetworks intends to examine a comprehensive range of timing options in 2019.

6.2. Assessing economic worth to the NEM

Given the number of variables affecting the energy sector, and the high level of uncertainty regarding future technology costs and emissions reduction policy, the evolution of the NEM is hard to predict for the life of a long-term infrastructure asset such as Marinus Link. To address this uncertainty, a set of plausible

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[66] NPV is a constant dollar measure of value which recognises the time value of money by discounting the value of future cash flows to a constant dollar value at a specified date using a discount rate that reflects the opportunity cost of capital. In this assessment, costs and benefits associated with Marinus Link over the period 2020 to 2050 were discounted to 2025 (the assumed commissioning date for Marinus Link) using a discount rate of 6 per cent.

[67] In general terms, the economic worth may include any change in economic efficiency generated by a project. The telecommunications benefits generated by Marinus Link (refer Section 6.4) could therefore be included in the economic worth if such benefits had been quantified. This assessment uses the term economic worth as an expression of the economic assessment result, rather than the RIT-T term net economic benefit, reflecting the fact that Marinus Link may provide additional economic efficiencies beyond the electricity market. This approach is consistent with Infrastructure Australia's guideline, Assessment Framework for initiatives and projects to be included in the Infrastructure Priority List, March 2018. At this stage, however, the only economic benefits that have been quantified relate to the NEM. For the purposes of this Report, the economic worth is therefore equivalent to the net economic benefit defined in the RIT-T.

[68] TasNetworks has commenced a RIT-T assessment of Marinus Link, which will be informed by the results of this initial feasibility study.

assumptions were made about the future development path of the NEM over the period to 2050, and the potential benefits from the operation of Marinus Link were evaluated based on those assumptions.

A neutral scenario, which follows most of the assumptions in AEMO's ISP 'Neutral case', was chosen to represent a credible evolution of the NEM. AEMO's Neutral case was chosen because it represents an extrapolation of the present state of the energy market, including current policy direction. It does not necessarily have a higher probability of occurring than other possible alternative scenarios.

Sensitivity analyses were then undertaken to understand the impact that adoption of different assumptions about the future development of the NEM would have on the modelling outcomes.

For the neutral scenario, and for each sensitivity examined, the economic worth of Marinus Link was obtained by subtracting the costs to implement Marinus Link from the benefits it provides.

6.2.1. Marinus Link NEM Benefits

TasNetworks identified a wide range of benefits brought about by Marinus Link. While all of these benefits add value to the project, only the NEM benefits can be considered in the RIT-T process, and must be assessed in accordance with the prevailing guideline for the RIT-T. Wider economic benefits, which accrue beyond the electricity market, are considered in Section 6.4.

The NEM benefits were quantified through a number of methods, as identified in Table 5.

Table 5 Marinus Link NEM benefits

Benefit	How quantified
i. Avoided capital costs of future generation and energy storage	EY market expansion model
ii. Reduction in operating and maintenance costs (including reduced fuel costs)	EY market expansion model
iii. Reduction in unserved energy	EY market expansion model
iv. Avoided spill from Tasmanian hydro storages	Tasmanian Electricity Market Simulation model[69]
v. Resilience benefits	Preliminary value from previous AEMO assessment
vi. Reduction of ancillary services costs	Preliminary TasNetworks calculations
vii. Avoided costs of future network upgrades	Preliminary TasNetworks calculations
viii. Power system security benefits	Not quantified to date
ix. Competition benefits	Not quantified to date
x. Option value	Not quantified to date

6.2.1.1. Benefits quantified by EY market expansion model

The benefit categories i – iii (refer Table 5: avoided capital costs of future generation and storage, reduction in operating and maintenance costs, and reduction in unserved energy) were assessed simultaneously via EY's proprietary electricity market expansion model. This model is the most complex part of the economic feasibility assessment, however the magnitudes of these categories of benefits are expected to be greater than any other benefit category, thereby justifying the increased effort to quantify them.

The EY electricity market expansion model was developed to determine the least cost long-term expansion of the NEM over the period 2020-2050[70]. The model takes the projected NEM demand over the study period as an input, and determines the optimal generation mix to supply this demand, to minimise the overall cost of supply to the entire NEM. The optimal generation mix may consist of both existing generation and assumed

[69] Tasmanian Electricity Market Simulation model is a detailed hydrological model of the Tasmanian hydro catchments, waterways and power stations
[70] Marinus Link would be expected to have a forty year design life, but modelling beyond 2050 was not possible due to the absence of demand forecast data beyond 2050.

new generation[71]. The model will determine the most appropriate timing and technology of new generation, and retirement of existing generation that reaches end of life or is uneconomic, across all NEM regions, to yield the overall least cost outcome over the entire study period. The model expresses the total cost of supply in NPV terms.

The model compares changes in NEM-wide costs in two different states of the future energy market: a state of the market without Marinus Link and an alternative state with Marinus Link in operation. The model will optimise the generation mix and minimise supply costs for each of these two states independently of each other, i.e. the forecast generation mix without Marinus Link and the forecast generation mix with Marinus Link will be different. The difference in NEM-wide resource costs between these two states of the market is then a measure of the net market benefits resulting from Marinus Link[72]. Marinus Link was modelled initially as a 600 MW interconnector, then as a 1200 MW interconnector implemented as two 600 MW stages.

The market expansion model assesses changes in the following cost components:

- **Capital costs** of new energy generation and storage capacity installed (corresponding to the investment necessary for the construction of such plant)
- **Total operation and maintenance costs** of all generation and storage capacity. This includes the cost of fuel.
- **Cost of unserved energy**, corresponding to the cost of electricity that cannot be supplied due to a lack of generation or interconnector capacity, valued at a given Value of Customer Reliability.

The market expansion model does not currently consider customer demand response, other than allowing unserved energy when this is more economic than building new generation to meet peak demand. Based on feedback received in response to the Project Specification Consultation Report, and acknowledging the increasing role demand response mechanisms may play in the future NEM, TasNetworks and EY are investigating how customer demand response may be incorporated into future modelling.

Further detail of the market expansion model can be found in Appendix 1.

The neutral scenario[73] used as the starting point in the EY market expansion model was based on the assumptions underpinning AEMO's ISP Neutral case. The main differences between the neutral scenario used for this assessment and the ISP's Neutral case are presented in Table 6. A key input to the market expansion model is the projected demand in each of the NEM regions, which was taken from AEMO's ISP Neutral case demand forecast. AEMO's demand forecast includes the impact of DER, such as rooftop solar

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[71] New generation types include traditional generation technologies, as well as large scale solar and wind generation, pumped hydro storage and grid scale batteries.
[72] This approach is consistent with that required by the RIT-T.
[73] EY's Market Modelling Report (Appendix 1) refers to the neutral scenario as the base case.

and distributed battery storage, hence the future uptake of these technologies is inherently included in Marinus Link studies[74].

In addition to the items in Table 6, the mainland NEM interconnector upgrades recommended for immediate progression/implementation in the ISP have been included in the EY market expansion model.

EY's model also treated inflows to Tasmanian hydro power schemes differently from the ISP, giving a more realistic representation of run-of-river schemes in particular. Refer to Appendix 1 for modelling details.

From this neutral scenario, a range of sensitivity studies were conducted for the purposes of understanding the impact of different model assumptions.

Table 7 summarises the neutral scenario and sensitivity assumptions and the reasons why they were investigated[75,76]. The sensitivities presented in Table 7 are grouped according to the impact upon the economic outcome. To manage the modelling effort and cost, a number of sensitivities were undertaken for the 600 MW link, but not reproduced for the 1200 MW link where the impact was not material.

Table 6 Key differences in assumptions between Marinus Link neutral scenario and ISP Neutral case

Assumption	Variation from ISP	Justification
Tasmanian wind generation prior to Marinus Link	ISP: 308 MW Marinus Link studies: 1050 MW	ISP only included existing wind generation (308 MW). No new wind generation was committed at the time. Marinus Link modelling adds a further 242 MW of wind generation committed since the ISP, and 500 MW based on connection applications being progressed by TasNetworks, which are considered likely to be commissioned prior to Marinus Link and are not dependent on the construction of Marinus Link.

[74] The full RIT-T analysis intended in 2019 will consider scenarios with alternative demand forecasts, thereby considering a greater range of DER outcomes.
[75] In addition to the sensitivities in Table 7, a number of sensitivities involving the assumption that additional wind generation or pumped hydro storage exist prior to Marinus Link were considered. These are reported in Appendix 1. However they are no longer considered valid because the underlying assumption in each, that the wind generation or pumped hydro storage would be built irrespective of whether Marinus Link proceeds, is not justifiable.
[76] The market expansion modelling had initially assumed Marinus Link would be fully operational in July 2025, for either the 600 MW or 1200 MW option. It later became apparent that the 1200 MW option would most likely be built as two x 600 MW stages, with the first 600 MW commissioned in 2025 and the second 600 MW in 2027 or 2028. Key 1200 MW sensitivities were repeated with the staggered commissioning approach. All results are presented in Appendix 1, but this chapter presents only the economic worth assuming staged commissioning.

Assumption	Variation from ISP	Justification
Victorian and Queensland government renewable energy target schemes	ISP: Victorian Renewable Energy Target (**VRET**) and Queensland Renewable Energy Target (**QRET**) both fully included Marinus Link studies: VRET is partially included; QRET not included.	VRET is included in Marinus Link studies to the extent it has been funded. QRET is not included because funding is not secured. A sensitivity was undertaken to examine the impact of including the full targets of both schemes, with the result that the full inclusion of these schemes had little impact on Marinus Link economic benefits (refer Section 6.3.2)
Pumped hydro storage costs	ISP: capex $1.49M/MW Storage capacity 6 hours Marinus Link studies: Tasmanian pumped hydro storage: $1.1M/MW; 24 hour storage capacity Mainland pumped hydro storage (except Snowy 2.0): capex $1.49M/MW Storage capacity 6 hours	Pumped hydro storage capacity and costs are highly dependent on geography of particular schemes. Tasmanian values updated to reflect Hydro Battery of the Nation report outcomes[77]. TasNetworks has undertaken additional investigation into how pumped hydro costs may vary by NEM region. This work, while not finalised, supports the view that Tasmania has a significant cost advantage compared to other NEM regions.
Wind, solar, hydro inflow traces	ISP: based on 1 year of historic data Marinus Link studies: based on repeating 7 years of historic data	Increased resolution and duration of Marinus Link studies allows for more realistic representation of multi-seasonal impacts and diversity of generation sources across regions.
Wind generation costs	ISP: VOM[78] = $15.73/MWh FOM[79] = $47.20/kW/year Lifetime = 20 years Marinus Link studies: VOM = $6/MWh FOM = $25/kW/year Lifetime = 25 years (Applied to all NEM regions)	Reflects recent data provided by developers and owners of existing wind farms.

[77] Hydro Tasmania, *Battery of the Nation – Tasmanian pumped hydro storage in Australia's future electricity market*, April 2018
[78] VOM = variable operation and maintenance (cost).
[79] FOM = fixed operation and maintenance (cost).

Table 7 Summary of neutral scenario and sensitivities examined

Sensitivity	Option	Assumptions	Why examined
Neutral scenario	600 MW and 1200 MW Marinus Link	• Generation development matched AEMO's committed projects list as of 20 April 2018, except for Tasmanian wind capacity prior to Marinus Link • Gas price: AEMO Neutral case • Basslink capacity: 478 MW • Emission reduction policy: 28 per cent reduction of 2005 emissions by 2030 and 70 per cent reduction by 2050 • Snowy 2.0: not commissioned • Marinus Link commission date: 2025	Represents a starting point that aligns generally with AEMO Neutral case, except for the assumptions described in Section 6.2.
Sensitivities resulting in a high impact on Marinus Link benefits			
High emissions reduction target	600 MW and 1200 MW	Emission reduction policy: 52 per cent reduction of emissions from 2005 levels by 2030 and 90 per cent reduction by 2050.	Implementation of emissions reduction policy based on CSIRO Low Emissions Technology Roadmap recommendations[80], as used in ISP fast change scenario.
300 MW load loss	600 MW	300 MW permanent load reduction in Tasmania	Represents loss of one or more large Tasmanian energy consumers which would significantly alter Tasmanian supply-demand balance; was considered in the Tamblyn study
Snowy 2.0 + high emissions reduction target	600 MW and 1200 MW	• Emission reduction policy: 52 per cent reduction of emissions from 2005 levels by 2030 and 90 per cent reduction by 2050. • Snowy 2.0 commissioned 2025 • AEMO ISP Vic-NSW upgrade Option 7A commissioned 2027	Plausible outcome of higher emissions reduction target is that Snowy 2.0 would become committed and Vic-NSW interconnector commissioned as early as possible

[80] CSIRO, *Low Emission Technology Roadmap*, https://www.csiro.au/en/Do-business/Futures/Reports/Low-Emissions-Technology-Roadmap

Sensitivity	Option	Assumptions	Why examined
Sensitivities resulting in a medium impact on Marinus Link benefits			
2032	600 MW	Marinus Link commissioning date: 2032	Timing sensitivity[81]
Sensitivities resulting in a low impact on Marinus Link benefits			
2028	600 MW	Marinus Link commissioning date: 2028	Timing sensitivity[81]
Gas price	600 MW	Gas price: AEMO ISP Strong gas price scenario	Potential high gas prices that would drive renewable energy development
Basslink 400 MW	600 MW	Basslink capacity: 400 MW	Represents the potential de-rating of Basslink due to unforeseen technical issues
100 MW load loss	600 MW	100 MW load reduction in Tasmania	Represents loss of one of a number of large energy consumers; would alter Tasmanian supply-demand balance
Full VRET and QRET	600 MW	Full VRET and QRET induced renewables developments included	Test whether assumption to include only funded portion of VRET in neutral scenario was unduly influencing outcomes
Snowy 2.0	600 MW	• Snowy 2.0: commissioned in 2025 • AEMO ISP Vic-NSW upgrade Option 7A commissioned 2034	Examine impact of Snowy 2.0 commitment

[81] The EY market expansion model is not able to optimise the timing of interconnectors, hence the impacts of timing variations were investigated via sensitivity studies. RIT-T analysis in 2019 will require determination of the optimal timing of Marinus Link.

6.2.1.2. NEM benefits assessed via other means

iv. Avoided spill from hydro storage

Spill from hydro storage is wasted energy that occurs when water arrives from upstream faster than it can run through the hydro plant, and spills from storages rather than being used to generate electricity. The presence of Marinus Link could alter hydro generator dispatch patterns to reduce the amount of spill. The energy saved could be used to offset more expensive sources of power generation.

Because the EY market expansion model is able to model wind spill but not hydro spill, TasNetworks engaged Hydro Tasmania to undertake a preliminary investigation into the possible benefits Marinus Link could provide by reducing spill from hydro storages. Hydro Tasmania uses a detailed hydrological simulation tool, Tasmanian Electricity Market Simulation model, to optimise its water management and power station dispatch. Further discussion of the modelling methodology is provided in Appendix 3. Taking the annual avoided spilled energy results from Tasmanian Electricity Market Simulation model modelling, the corresponding value of avoided spilled energy for each year of the study was calculated using that year's average value of the Victorian wholesale price simulated by the EY market model[82].

Hydro Tasmania conducted the avoided spill calculation for the neutral scenario adopted in the EY modelling, with both 600 MW and 1200 MW Marinus Link options. Average estimated quantity of spill reduction, and corresponding present value of energy saved over the study period, are:

- 600 MW Marinus Link: 124 GW per year of averted spill, with a total value of $127 million; and
- 1200 MW Marinus Link: 130 GW per year of averted spill, with total value of $131 million.

These results were assumed for all sensitivities other than 2028 or 2032 Marinus Link commissioning[83].

v. Resilience benefits

Resilience benefits is a term previously used by AEMO to refer to, "the benefits derived from increasing the power system's resilience to high impact, low probability events such as interconnector failures. Resilience benefits are not a separate category of benefits, but a subset drawn from existing categories of RIT-T allowable market benefits"[84].

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[82] Tasmanian Electricity Market Simulation model modelling could determine the quantity of spilled water which Marinus Link could avoid, but it could not determine precisely when that water would be subsequently utilised. It is reasonable to assume the water will be used to either increase power exports from Tasmania (at times of high Victorian wholesale prices), or reduce power imports into Tasmania (which occur at times of low Victorian prices). On this basis and in the absence of better information, the average Victorian wholesale price was assumed.
[83] The spill benefits were reduced for the two sensitivities where Marinus Link is commissioned in 2028 or 2032. Only spill savings beyond the commissioning year were considered. The benefits were $116 million (for 2028 commissioning) and $69 million (for 2032 commissioning). These values are discounted to 2025.
[84] AEMO, *National Transmission Network Development Plan*, 2016, p.27

Without Marinus Link, an unplanned outage of Basslink could result in increased generation costs. This is because Tasmanian gas generation, which is normally maintained in a state of reduced operational readiness, would be required to return to service to supplement Tasmanian hydro, wind and solar generation. Mainland NEM regions would also be deprived of access to generation from Tasmania, resulting in increased gas generation, with consequences for dispatch cost and efficiency, and possible supply reliability consequences during peak demand days.

The presence of Marinus Link would provide an alternative power flow path between Tasmania and Victoria, thereby eliminating these costs to both mainland NEM regions and Tasmania in the event of an outage of Basslink.

The resilience benefits have been previously estimated by AEMO based on the simulated differences in market costs with and without the presence of an interconnector, if Basslink was unavailable for a year. The benefit itself is weighted using a 5 per cent probability of occurrence, representing a 1-in-20-year expectation of the 12-month outage[85]. The resulting benefit of $49 million has been included as a preliminary value in this assessment.

A further benefit is the one-off use of the additional water that Hydro Tasmania is now required to maintain in storage to ensure sufficient water reserves in the event of a prolonged outage of Basslink[86]. The presence of Marinus Link could allow a relaxation of these more conservative water storage targets, because the second interconnector would provide the required energy security. This would allow greater dispatch flexibility of Hydro Tasmania's generators, as well as the one time use of the water currently held in storage. A preliminary estimate of the value of this one-off water release is $50 million, however it has not been included in this assessment because it would be double-counting part of the resilience benefits estimated by AEMO, and there is uncertainty about the magnitude of reduction of water storage targets that would be permitted. Further assessment of this water value and re-calculation of the previous resilience benefits will be undertaken in future work.

vi. Reduction of ancillary services costs

Ancillary services perform the essential role of ensuring stable power system operation on a minute-to-minute basis, especially when subjected to unforeseen contingency events. While generators and other network devices directly provide ancillary services, interconnectors offer the ability to transfer some types of ancillary services between regions, thereby lowering the overall cost of ancillary services within the NEM.

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[85] AEMO, *National Transmission Network Development Plan*, 2016, p.31

[86] Following the 2016 outage of Basslink, the Tasmanian Energy Security Taskforce recommended Hydro Tasmania maintain its storages at higher levels. This increases the probability that, should a prolonged outage of Basslink occur, Tasmania would be able to meet its energy needs without incurring any additional expense.

Marinus Link would have the potential to transfer some categories of ancillary services between regions, and also provide some categories of ancillary services directly.

The future requirement for ancillary services is uncertain because the ability of newer generation technologies to provide ancillary services is still evolving. However, with the gradual replacement of thermal generation by renewable generation, ancillary services are likely to be in greater demand and of higher value in future. The assessment of ancillary services cost reductions, which Marinus Link may offer, is therefore preliminary and should be taken as an indication of the potential benefits which could arise.

Ancillary services benefits already identified via preliminary calculations include:

- Frequency control ancillary services savings (**FCAS**): a present value of $12 million over 25 years is known to be the minimum achievable[87], but this could potentially be in the order of $100 million if Marinus Link can be demonstrated to reduce the NEM-wide requirements for some categories of FCAS. $12 million has been conservatively assumed in this economic assessment.
- System Restart Ancillary Services (**SRAS**): Marinus Link could provide system restart services in both Tasmania and Victoria, reducing the requirement for AEMO to procure equivalent services from generators. Preliminary estimates of savings, based on existing SRAS costs, have an NPV of $42 million for the period 2025 to 2050[88].

Marinus Link also has the potential to reduce the requirements for inertia services, network support and control ancillary services, and it could also contribute to system strength. The quantities of each of these services Marinus Link could provide, and the resulting benefits, have not been examined to date.

Substantial work to quantify the ancillary services benefits will be undertaken in 2019.

vii. Avoided future network upgrades

Marinus Link would require network upgrades to be able to operate. If the 1200 MW Marinus Link option was constructed, portions of these network upgrades would reduce the cost to expand transmission capacity in northern Tasmania to facilitate additional renewable generation connection. This represents a saving to other projects.

To quantify these benefits for this study, TasNetworks undertook an internal estimation of the avoided network costs based on network planning. The avoided network cost is about $40 million, applicable only for the 1200 MW Marinus Link option.

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[87] This minimum estimate is based on the avoided requirement for Tasmania to provide FCAS locally every time the direction of power flow across Basslink is reversed. With Marinus Link operating in parallel to Basslink, this requirement for local ancillary services during Basslink reversals would be eliminated. The savings have been estimated to be $1 million per year.

[88] Based on the assumption that Marinus Link would negate the requirement for one SRAS generator contract in the Latrobe Valley and one in northern Tasmania.

Locating the Victorian converter station in the Latrobe Valley could potentially result in avoided asset retirement costs in the Victorian network. TasNetworks is working with AusNet Services to quantify these potential cost savings.

6.2.1.3. Other NEM benefits to be quantified

The following NEM benefits have not yet been evaluated:

viii. Power system security benefits: Power system security refers to the ability of a power system to remain in a satisfactory state[89] following a contingency event. The progressive replacement of large thermal generating units by non-synchronous generators is expected to increase the difficulty in maintaining power system security, resulting in dispatch inefficiencies if higher cost synchronous generation must be dispatched to maintain power system security[90]. Marinus Link has the potential to assist in maintaining power system security in both the broader NEM and Tasmania.

ix. Competition benefits: The present reliance on a single interconnector limits the ability of generators and retailers on opposite sides of Bass Strait to enter into power purchase contracts, due to the need for secondary arrangements in the event that Basslink is out of service. The presence of Marinus Link should remove this barrier, giving more retailers greater contract access to Tasmanian generation, and allowing increased retail offerings in Tasmania backed by access to wider NEM generation.

x. Option value: The implementation of the 1200 MW Marinus Link option as 2 x 600 MW stages potentially allows option value to be captured. The first 600 MW could be implemented in the mid-2020s, with the second 600 MW being implemented at a later time depending on the evolution of the electricity market.

These classes of benefits have not been evaluated to date because their value was initially expected to be smaller than that of other benefit categories. TasNetworks chose to utilise its resources to evaluate those categories of benefits expected to deliver the greatest value. These three categories of benefits will be examined in 2019[91], and are expected to further increase the net worth of Marinus Link.

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[89] A satisfactory operating state broadly means voltage and frequency are within limits and no equipment is overloaded.

[90] Synchronous generating units (e.g. gas, coal, hydro) inherently contribute to the management of power system security via the ancillary services they provide. Non-synchronous generating units (e.g. wind, solar) make substantially less contribution.

[91] TasNetworks intends to publish Marinus Link Project Assessment Draft Report by July 2019. Work to examine these areas will therefore be accorded high priority in early 2019. TasNetworks has commenced discussions with EY regarding modification of the market expansion model to include power system security considerations.

6.2.2. Marinus Link Costs

The investment and operational costs of Marinus Link are deducted from the benefits discussed previously, to calculate the economic worth of Marinus Link. These cost estimations include the capital expenditure (**capex**) and operating expenditure (**opex**) estimates for the lifetime of the project including the Definition and Approvals phase costs. At this stage of the feasibility study TasNetworks has not developed a detailed probabilistic cost estimate. The cost components considered for the purposes of economic worth calculation are the base costs and interest during construction. Contingency, accuracy and escalation allowances (refer section 7.6) are excluded. TasNetworks' methodology for determining base costs, using data from past projects[92], results in a base cost being equivalent to a P50 cost[93].

Marinus Link is expected to have a 40 year asset life, yet the economic benefits modelling only considers Marinus Link's operation to 2050[94]. To ensure a valid cost-benefit comparison, it is necessary to ensure the time periods used for calculation of the costs and benefits align.

The approach of comparing the NPV of the annualised costs of Marinus Link with its expected benefits over the study period (i.e. 2025-26 to 2049-50) has been taken. Both costs and benefits are discounted to 1 July 2025, being the assumed commissioning date of Marinus Link. The costs considered are the annualised capital costs (including financing cost over the 40 year asset life) and the annual opex costs. The most expensive of the favoured route options was chosen for costing purposes. For the two sensitivities in which Marinus Link is commissioned later (2028 and 2032), an equivalent methodology is used, but the NPV of costs is calculated over the reduced operational period to 2050.

Table 8 presents the costs used for economic worth calculation for the 600 MW Marinus Link option (assumed to be commissioned in 2025), the 1200 MW Marinus Link option, and for the two sensitivities in which the 600 MW Marinus Link was assumed to be commissioned in either 2028 or 2032.

The 1200 MW option is assumed to be constructed and commissioned in two 600 MW stages, being commissioned in 2025 and 2028. The annualised costs shown in Table 8 for the 1200 MW option apply to years 2028 onwards, when both stages are present. Although not shown in Table 8, the lower annual costs in the years from 2025 to 2028, when only one stage would be in service, are included in the detailed modelling.

[92] This considers both TasNetworks past costs, and publicly available cost data for Australian and international projects.
[93] In line with guidance from Infrastructure Australia's Assessment Framework, March 2018, 'D3.4 Expected value of costs' p.101. P50 costs are estimates of project costs based on 50 percent probability that the cost estimate will not be exceeded.
[94] This implicitly assumes that the benefits and costs during the final 15 years of Marinus Link's life would be equal, which is arguably unrealistic. Due to the long forecast period and the scale of transformation anticipated in the NEM, any attempt to model beyond 2050 could also be argued to be of limited value. Furthermore, discounted costs during the final 15 years of a forty year asset life, with 6 per cent cost of capital, represent only 15 per cent of the total asset cost. For these reasons, no attempt was made to either extend the market expansion model beyond 2050, nor extrapolate benefits accruing in the final year(s) of the modelling beyond 2050.

Table 8 Costs used for economic feasibility assessment

	600 MW (2025 commissioning) ($M)	1200 MW (2025 and 2028 staged commissioning) ($M)	600 MW (2028 commissioning sensitivity) ($M)	600 MW (2032 commissioning sensitivity) ($M)
Capital cost[95,96]	1357	2450	1357	1357
Annual operating cost	18	26	18	18
Annualised total cost for economic analysis[97]	108	189	108	108
Present value of Marinus Link cost over study period	**1385**	**2198**	**1095**	**780**

6.3. NEM economic worth outcomes

This section presents the key outcomes of the economic studies carried out as part of this initial feasibility study.

Of the methods that quantify NEM benefits discussed in Section 6.2, only the EY market expansion model could differentiate benefit outcomes between the various sensitivity cases in Table 7. All other categories of market benefits had common preliminary values applied across all sensitivities for a given Marinus Link capacity. Therefore, for a given Marinus Link capacity, any change in NEM benefits will be entirely due to the outcome of the EY market expansion model[98].

In this section, results for each sensitivity are presented in terms of the economic worth (i.e. the benefits minus the costs). This differs from how results are presented in EY's Market Modelling Report (Appendix 1) which presents results in terms of benefits only.

[95] Because our cost estimating methodology (refer Chapter 7) determines base costs on a P50 basis, the contingency and accuracy allowances are excluded from both capital and operations and maintenance costs for the purposes of this cost benefit analysis.
[96] Capital cost excludes the cost of the Sheffield-Palmerston transmission line upgrade on the basis that this is a contingent project in TasNetworks' 2019-2024 revenue proposal, expected to be triggered independently of, and prior to, Marinus Link.
[97] Annualised cost is the annualised capital cost including finance cost (assuming a forty year asset life and 6 per cent cost of capital) plus the annual operations and maintenance cost.
[98] With the exception of the sensitivities involving deferral of the 600 MW Marinus Link, as these have a lower portion of the capital cost within the study period.

6.3.1. Neutral scenario outcomes

Appendix 1 provides considerable discussion about the future evolution of the NEM in the neutral scenario[99], which is summarised here.

The notable outcome in the neutral scenario is the shift in the NEM generation mix towards renewables and a progressive exit of coal-fired generation, a result consistent with ISP findings. Renewable generation is developed in all states, thereby capitalising on the diversity of renewable resources across the NEM.

Outcomes without Marinus Link

Under the neutral scenario, in the absence of Marinus Link, no further transmission-connected renewable generation is forecast to be developed in either Victoria[100] or Tasmania until the early 2030s when Victorian coal-fired generators are expected to commence retirement. From the early 2030s onwards, additional renewable generation (both wind and solar) and pumped hydro storage would be built in Victoria, with Victorian pumped hydro storage forecast to reach 1 GW – the maximum limit assumed in the model – by 2040. The model indicates that solar generation would be built in Tasmania in the 2030s, and as Tasmanian wind generation reaches its end of life and retires it would be replaced with solar generation. No pumped hydro storage would be developed in Tasmania until the late 2040s. Basslink flows are forecast to be predominantly northwards to Victoria, at its maximum transfer limit more than 45 per cent of the time.

This indicates that as renewable generation starts to replace coal-fired generation in the NEM in the 2030s and beyond, the limited Bass Strait interconnector capacity would constrain the development of Tasmania's abundant renewable energy resources. Any renewable generation developed in Tasmania would be predominantly used locally, allowing Tasmanian hydro generation to be better utilised at higher value at times of higher Victorian demand. Because Tasmania's hydro system can absorb the variations in either solar or wind generation, then solar, being cheaper than wind by the 2030s, would be developed in preference to wind.

Outcomes with Marinus Link installed

With Marinus Link installed in the mid-2020s with a capacity of 600 MW under the neutral scenario, the additional interconnection capacity would make it more economic to develop additional renewable generation and pumped hydro storage in Tasmania from 2030, with less capacity being developed in Victoria and South Australia. Investment in additional Tasmanian wind generation would be economic from 2030, and in pumped hydro storage and large solar generation from the mid-2030s as coal-fired generation progressively retires. Approximately 500 MW of Tasmanian pumped hydro storage becomes economic from the

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[99] EY's Market Modelling Report refers to the neutral scenario as the base case.
[100] Noting that in the Neutral Scenario, the VRET 2025 target was not implemented. The VRET + QRET sensitivity (refer Section 6.3.2) showed the full implementation of VRET had only a marginal impact on the economic worth of Marinus Link. It did, however, result in 3 GW of renewable generation in Victoria being brought forward to 2024-25 in Victoria (refer Appendix 1).

mid-2030s, reducing the requirement to develop more expensive pumped hydro storage in Victoria and South Australia.

With the second stage of Marinus Link installed in 2028, increasing the capacity to 1200 MW, additional Tasmanian wind generation would be developed in the late 2020s, and further development would continue throughout the 2030s and 2040s. Tasmanian pumped hydro storage would be built at a similar time to the 600 MW Marinus Link case (approximately 2034) but the economically viable capacity would be doubled with the 1200 MW interconnector, further reducing the requirements for Victorian and South Australian pumped hydro storage. These Tasmanian energy resource developments would avoid the need for investment in and operation of higher cost thermal generation sources and would also replace some higher cost renewables developments in the broader NEM.

The presence of Marinus Link also increases Victorian supply reliability, with the quantity of unserved energy being reduced with either 600 MW or 1200 MW Marinus Link capacity.

With Marinus Link of either capacity, energy flows on both Marinus Link and Basslink would be mainly towards Victoria, with greater capacity also for imports to Tasmania at times of generation surplus (and low prices) in other NEM regions[101].

The benefits generated by Marinus Link are $845 million and $1154 million for the 600 MW and 1200 MW capacities respectively, due mainly to fuel and capital cost savings in other NEM regions (principally Victoria and to a lesser extent NSW, SA and Queensland). That is, the resource cost of investments in and operation of lower cost Tasmanian energy resources would provide a benefit to the NEM, by avoiding the need to resort to higher cost generation options in other NEM regions.

While the neutral scenario modelling shows Marinus Link would make Tasmanian renewables development economically feasible and generate substantial benefits across the NEM, in the neutral scenario the costs of Marinus Link would exceed the benefits it would provide, even after including other benefits not captured by EY's model. This applies for both the 600 MW and 1200 MW options. Estimates of the economic worth of Marinus Link under the neutral scenario are summarised in Table 9.

Deeper analysis reveals this is because the benefits delivered by Marinus Link would occur predominantly from 2035 through to 2050. This is when Marinus would provide lower cost solutions to address the retirement of coal-fired generation forecast under the neutral scenario. Because the benefits would occur later in the study period, their NPV is more heavily discounted than if the benefits had occurred soon after

[101] Marinus Link would therefore enable Tasmania's conventional and pumped hydro storage resources to be operated as a large scale battery for the NEM, exporting and importing electricity to and from Tasmania to maximise its value to Tasmania and the NEM as a whole.

Marinus Link commissioning. This indicates that under neutral scenario assumptions, the commissioning of Marinus Link in the mid-2020s would be premature.

Table 9 Economic worth of Marinus Link in the neutral scenario with 2025 commissioning[102]

Marinus Link Neutral Option – 2025	600 MW ($M)	1200 MW[103] ($M)
Capex savings	87	64
Fixed operating cost savings	59	87
Variable operating cost savings	664	975
Reduction of unserved energy	35	28
Total benefits from EY market model	**845**	**1154**
Ancillary services	54	54
Avoided spill	127	131
Energy security	49	49
Avoided future network upgrades	0	40
Tamar Valley Power Station (**TVPS**) stays in service[104]	40	40
Total additional benefits	**270**	**314**
Total Marinus Link benefits	**1115**	**1468**
Marinus Link costs	**1385**	**2198**
Economic worth	**(270)**	**(730)**

[102] The economic worth calculation considers only the period to 2050.
[103] The market model benefits presented in this table for the 1200 MW Marinus Link option are for the staggered implementation schedule, as per Section 3.3.2 in Appendix 1.
[104] After undertaking the modelling, it was realised that an incorrect assumption had been made regarding the operation of TVPS: the assumption was made that this plant would not operate, while in reality this plant can operate when it is economically viable to do so. A subsequent study (detailed in Appendix 1) showed that the operation of TVPS can deliver approximately $40 million in NEM benefits when Marinus Link is commissioned. This additional benefit has been subsequently applied to all results, other than 2028 commissioning ($20M conservatively applied), 2032 commissioning ($10M applied) and 300 MW load loss ($0M applied, on the basis that a large loss of load would yield such an energy surplus in Tasmania that there would be no economic reason to operate TVPS).

6.3.2. Overview of sensitivity results

Table 10 summarises the sensitivity studies undertaken, and the difference in economic worth from the neutral scenario. Unless noted otherwise, 600 MW of Marinus Link capacity is commissioned in 2025, with the second 600 MW (for the 1200 MW option) commissioned in 2028.

Table 10 Summary of results of sensitivity studies

Sensitivity	Economic worth ($M)		Difference from Neutral ($)	
	600 MW	1200 MW	600 MW	1200 MW
Neutral scenario	-270	-730	0	0
High emissions reduction target	490	482	+760	+1213
Snowy 2.0	-377	-	-107	-
Snowy 2.0 + high emissions reduction target	114	40	+384	+771
300MW load loss	477	-	+747	-
100 MW load loss	-127	-	+143	-
Basslink 400 MW	-120	-	+150	-
High gas price	-185	-	+85	-
Full VRET and QRET	-281	-	-11	-
2028 commissioning	-117	-	+153	-
2032 commissioning	4	-	+274	-

The sensitivities which had the most significant impact on the economic outcomes are the higher emissions reduction target (whether or not coupled with Snowy 2.0) and a 300 MW load loss. These are discussed in detail in Section 6.3.3.

Section 6.3.3.3 examines the impact in the timing of commissioning of Marinus Link under the neutral scenario assumptions.

Apart from emissions reduction and load loss sensitivities (with or without Snowy 2.0), discussed further below, the remaining sensitivity studies resulted in negative economic worth. Although in some cases the benefits increased by over $100 million compared with the neutral scenario, this is not sufficient to result in an overall positive economic worth. Further discussion about these results may be found in Appendix 1.

6.3.3. Significant sensitivity results

A high emissions reduction target, or the loss of 300 MW of Tasmanian load, both have a significant positive impact on the economic worth of Marinus Link. The expected impact of alternative commissioning timing of Marinus Link, with all other inputs unchanged from the neutral scenario, is also discussed. The impacts are explained in detail in Appendix 1, and are summarised here. Table 11 presents the overall results.

Table 11 Economic worth of Marinus Link for significant sensitivities

Sensitivity	High emissions reduction target ($M)		High emissions reduction target + Snowy 2.0 ($M)		300 MW load loss ($M)
Marinus Link option	600 MW	1200 MW	600 MW	1200 MW	600 MW
Capex savings	734	1,154	444	710	206
Fixed operating cost savings	102	248	38	172	85
Variable operating cost savings	763	930	718	949	1292
Reduction of unserved energy	6	34	29	94	47
Total benefits from EY market model	**1605**	**2366**	**1229**	**1925**	**1630**
Ancillary service	54	54	54	54	54
Avoided spill	127	131	127	131	130
Energy security	49	49	49	49	49
Avoided future network upgrades	0	40	0	40	0
TVPS stays in service[105]	40	40	40	40	0
Total additional benefits	**270**	**314**	**270**	**314**	**233**
Total Marinus Link benefits	**1875**	**2680**	**1499**	**2239**	**1863**
Marinus Link costs	**(1385)**	**(2198)**	**(1385)**	**(2198)**	**(1385)**
Economic worth[106]	**490**	**482**	**114**	**40**	**477**

[105] After undertaking the modelling, it was realised that an incorrect assumption had been made regarding the operation of TVPS: the assumption was made that this plant would not operate, while in reality this plant can operate when it is economically viable to do so. A subsequent study (detailed in Appendix 1) showed that the operation of TVPS can deliver approximately $40 million in NEM benefits when Marinus Link is commissioned. This additional benefit has been subsequently applied to all results, other than 2028 commissioning ($20M conservatively applied), 2032 commissioning ($10M applied) and 300 MW load loss ($0M applied, on the basis that a large loss of load would yield such an energy surplus in Tasmania that there would be no economic reason to operate TVPS).

[106] Values in the table have been rounded to nearest $1 million. Totals may appear to be incorrect by $1 million due to rounding. Economic worth values have been rounded to nearest $10 million for chapter summary and executive summary.

6.3.3.1. High emissions reduction target

Regardless of Tasmanian interconnector capacity, the impact of a higher emissions reduction target would be to drive an earlier reduction in coal-fired generator output (with commensurate earlier power station closures), and a vast increase in the development of renewable generation technologies across the entire NEM[107]. Storage capacity would also increase, and in the final years of the study pumped hydro storage capacity limits in mainland NEM regions would be reached in the absence of Marinus Link[108].

In the high emissions reduction sensitivity, without Marinus Link, Basslink would export at its capacity limit for much of the time, leaving limited opportunity to increase exports further despite the increased requirement for dispatchable on-demand renewable energy in mainland NEM regions. The energy requirements of mainland NEM regions would be supplied from new gas and renewable generation developed on mainland Australia.

Marinus Link, assumed to be commissioned from 2025, would have a significant positive impact on the NEM in the high emission reduction target sensitivity. It would become economic to develop more Tasmanian wind from the year Marinus Link is commissioned, and to substantially develop Tasmanian pumped hydro storage resources by the late 2020s. Development of Tasmanian renewable generation would then continue into the 2030s and 2040s. Under this sensitivity, the diversity and more flexible use of lower cost Tasmanian energy resources relative to available mainland NEM resources would:

- reduce the need for open cycle gas turbines in mainland NEM regions;
- reduce investment in large scale battery storage in mainland NEM regions; and
- complement the variable production patterns of the growing renewable generation fleet on mainland NEM regions.

Under the high emission reduction target sensitivity, modelling indicates Marinus Link would generate benefits of $1605 million and $2366 million for 600 MW and 1200 MW options respectively. This mainly comprises fuel and investment cost savings in mainland NEM regions (primarily in Victoria, but with benefits also realised in Queensland, NSW and SA) enabled by significant Tasmanian investments in pumped hydro storage, wind and solar capacity, facilitated by Marinus Link. When preliminary estimates of the other unmodelled economic benefits are included and Marinus Link costs subtracted, under this high emissions

[107] Some stakeholders have proposed that TasNetworks should explicitly examine early coal-fired retirement in the absence of an emissions reduction target. This leads to the question of what assumptions to make with regard to retirement dates of particular plant, given the absence of such information in the public domain. The advantage of modelling an emissions reduction target is all required information is publically available and therefore provides a justifiable basis for the results.
[108] As per Table 6 Marinus Link studies assumed 1000 MW per NEM region limit of pumped hydro capacity (excepting Snowy 2.0), which was not adopted in the ISP.

reduction sensitivity Marinus Link would have a positive economic worth of $490 million for the 600 MW option and $482 million[109] for the 1200 MW option.

Emissions reduction targets do not, of themselves, drive the high economic worth of Marinus Link under the high emissions reduction sensitivity. Rather, the emissions reduction target results in lower generation output from coal-fired power stations, then closures occur because the model determines it is uneconomic to continue to maintain these power stations which are less utilised. Marinus Link and renewable generation in mainland NEM regions are both required to fill the supply gap left by the closure of coal-fired power stations. Figure 19 shows the reduction in coal-fired generation capacity projected by EY's market expansion model in both the neutral scenario and the high emissions reduction sensitivity. By about 2028-2029, the reduction in coal-fired generating capacity since the start of the study is about 7 GW (i.e. 7000 MW) in the high emissions reduction sensitivity, a reduction of about 5 GW of black coal-fired and about 2 GW of brown coal-fired generation. These levels of capacity reduction occur in the mid-2030s in the neutral case, when retirements are driven by plant reaching the end of design life.

Figure 19 Retirement of coal-fired generators in neutral scenario and high emissions reduction sensitivity[110]

[109] Rounded to nearest $10 million ($480 million) when discussed elsewhere in this Report.
[110] The nature of the market expansion model will allow capacity reductions less than a power station's total capacity. This broadly reflects the possibility of generators retiring some individual generating units earlier than others. The total generating capacity in 2020 is less than the currently installed capacity, because the market expansion model determined that a lower cost outcome would result if some plant was retired at the very start of the modelling period.

Emissions reduction targets may also be achieved via state-based renewable energy schemes and there are potentially other factors, often not transparent, which could cause coal-fired generation to retire early. Examples include the inability of the plant to respond, without degradation of performance, to more onerous duty cycles which will occur as more renewable generation is developed. Secondly, plant upgrades (required to ensure continued reliable operation) may need to meet stricter health, safety and environmental standards than when the plant was first commissioned, making upgrades expensive and potentially uneconomic. AEMO's 2018 Electricity Statement of Opportunities highlighted the increasing outage rates being experienced within the coal-fired generation fleet in recent years[111], indicating that the reliability and economic viability of the fleet is decreasing.

The Snowy 2.0 project can potentially provide a large portion of the energy storage required as coal-fired generation is replaced by variable renewables. The presence of Snowy 2.0, along with the ISP recommended upgrade of the Vic-NSW interconnector (SnowyLink South)[112], was therefore considered as a logical extension of the high emissions reduction sensitivity. The results of the high emissions reduction plus Snowy 2.0 sensitivity show that, although Snowy 2.0 would reduce the economic worth of Marinus Link compared with the high emissions reduction sensitivity, the 600 MW option would still have an economic worth of $114 million and the 1200 MW option would be $40 million. This indicates that the quantum of coal-fired generation that is anticipated to be retired under a high emissions reduction target – almost 20 GW by 2050[113] – is such that the construction of Marinus Link, plus the increased Tasmanian renewables and pumped hydro developments which ensue, provide economic value in addition to Snowy 2.0 to assist in the energy transformation of the NEM.

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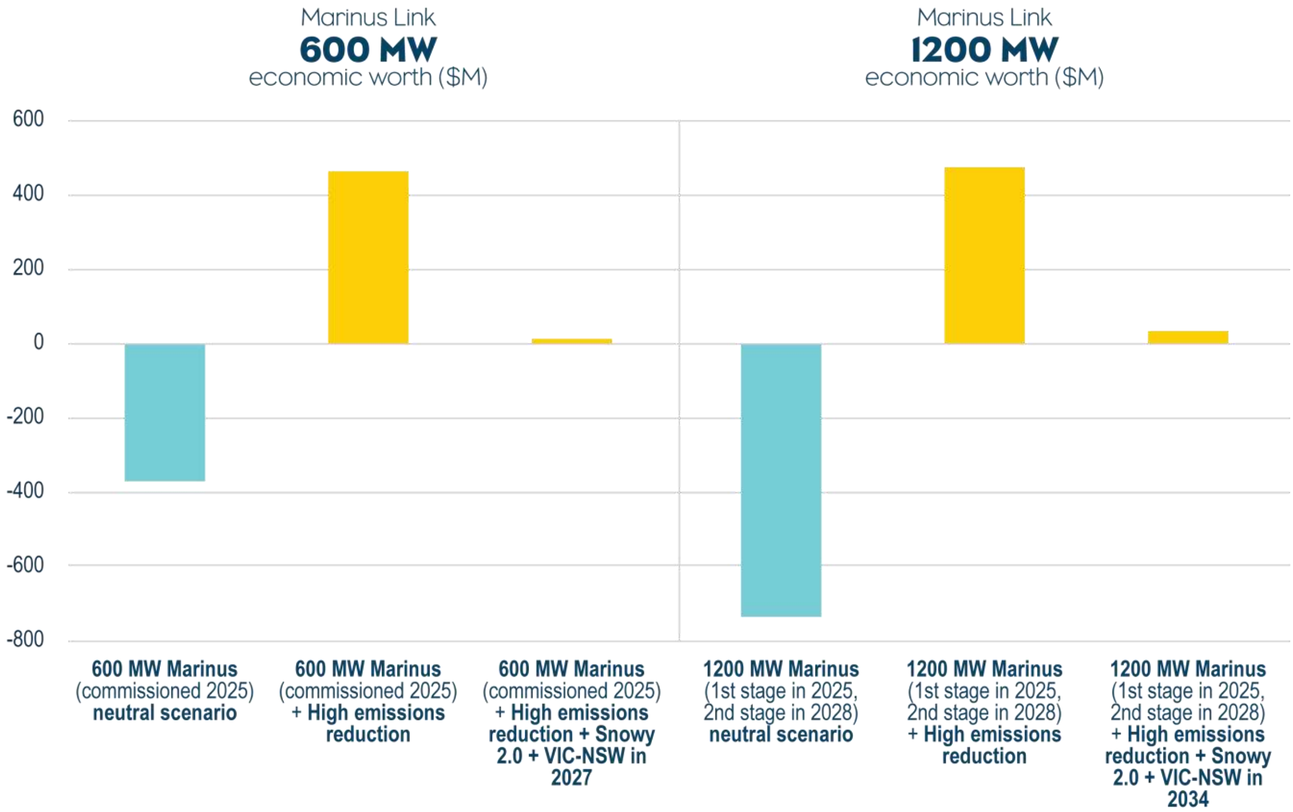
[111] AEMO, *2018 Electricity Statement of Opportunities*, August 2018, p.21

[112] When considering the year in which SnowyLink South should be assumed to be operational in a high emissions reduction + Snowy 2.0 sensitivity, the initial assumption was SnowyLink South should be commissioned as early as practicable, i.e. approximately 2027. A second sensitivity, assuming a 1200 MW Marinus Link, was later conducted with all things being equal other than SnowyLink South being commissioned in 2034. When the capital cost deferral of SnowyLink South from 2027 to 2034 was included, the second sensitivity resulted in higher benefits than the sensitivity with SnowyLink South commissioned in 2027. This suggests that 2027 may be earlier than economically optimal timing of SnowyLink South, and the results with SnowyLink South commissioned in 2034 are presented in this section. This sensitivity was not repeated for the 600 MW Marinus Link option.

[113] Refer to Figure 25 of Appendix 1

Figure 20 Economic worth in differing emissions reduction sensitivities



6.3.3.2. Loss of significant Tasmanian load

The final sensitivity of note is the potential loss of 300 MW of load. Tasmania has a number of large industrial load customers, whose operations are exposed to international commodity prices and currency fluctuations. While the loss of 300 MW load is highly undesirable and TasNetworks is not aware of any reason why it should occur in the short or medium term, it is nevertheless conceivable.

In the event of loss of 300 MW of load, Tasmania would have a net energy surplus which could not all be transferred to mainland NEM regions due to the limited capacity of Basslink. This would ultimately result in spill of hydro and/or wind energy. The presence of Marinus Link would allow this surplus energy to be exported to mainland NEM regions at a lower cost than equivalent mainland generation. In this case, Marinus Link has a positive economic worth of $477 million.

TasNetworks does not advocate that Marinus Link should be constructed for the purposes of allowing energy transfer following the hypothetical loss of a large customer. This result does show, however, that Marinus Link has the potential to provide value in this undesirable situation.

6.3.3.3. Effects of Marinus Link timing

The neutral scenario assumes a 600 MW Marinus Link is commissioned in 2025, and the economic worth was found to be -$270 million. If all other model parameters were unchanged, but the commissioning year changed to 2028, the economic worth under the neutral scenario increased to -$117 million. Changing the commissioning year to 2032 with neutral assumptions resulted in a marginally positive economic worth of $4 million[114]. This trend in increasing economic worth of Marinus Link under the neutral scenario assumptions, but with later commissioning is due to two factors. Firstly, the benefits of Marinus Link accrue predominantly from the time coal-fired generation retires, and closer alignment of Marinus Link commissioning with the period of large scale coal-fired generation retirement would therefore increase the benefits Marinus Link can deliver. Secondly, the deferral of capital costs due to later commissioning would also effectively reduce the cost of Marinus Link in present value terms.

Deeper analysis of modelling results for a 600 MW capacity Marinus Link reveals that the new generation constructed in the NEM in the 3-year period from 2032 to 2035 is not materially influenced by Marinus Link. So, if Marinus Link was constructed in 2035 instead of 2032, there would be a further increase in its economic worth, due to the deferral of capital cost. A Marinus Link of 600 MW capacity would therefore have a positive economic worth if commissioned in 2035 under neutral scenario assumptions. This timing is broadly consistent with AEMO's ISP analysis and will be subject to further detailed modelling in 2019.

The impacts of changes in timing of commissioning of a 1200 MW Marinus Link have not been investigated explicitly, although there is no evidence to suggest that similar trends would not be observed. TasNetworks intends to undertake this work in 2019.

6.4. Wider economic benefits

Wider economic benefits occur beyond those directly attributable to the NEM. Under the present RIT-T these cannot be included, as they do not accrue directly to consumers and producers of electricity. They do however provide a benefit to society, and thus their inclusion results in a more comprehensive view of the project's value and impact. The RIT-T process recognises that Governments may value and provide funding to achieve these benefits. This may reduce costs to be recovered from electricity customers and support an investment outcome under the RIT-T or under other interconnector service models. On that basis, these wider benefits were assessed drawing on information from Project Marinus Economic Contribution analysis undertaken by EY.

[114] The $4 million net economic result is derived as follows: from Section 3.2.10 of Appendix 1, the present value of benefits for the 2032 commissioning is $905M (discounted to 2032). Discounting this to 2025 at 6 per cent WACC reduces the value to $602M. Add benefits from ancillary services ($54M), avoided spill ($69M for the 2032 commissioning), energy security ($49M), and TVPS remaining in service ($10M for 2032 commissioning) yields total benefit of $784M. Subtract 2032 project costs ($780M, Table 8) to give economic worth of $4M.

i. Economic stimulus due to construction and operation of Marinus Link

The estimate of the economic stimulus created by the investment in Marinus Link includes all the direct and indirect revenues and outputs created throughout the construction and operations phases of the link.

This analysis has been undertaken by EY using REMPLAN software, an economic analysis software designed for use by economic development practitioners to estimate the direct and indirect impacts of infrastructure developments (see details in Appendix 2).

ii. Economic stimulus due to investments in renewable generation projects induced by construction and operation of Marinus Link

Marinus Link will lift constraints on the current Tasmanian transmission network and therefore induce investments in new renewable generation across Tasmania[115].

In Victoria, Marinus Link would support cost effective dispatchable on-demand energy, including by slightly reducing the amount of renewable generation development that is required in Victoria. On this basis the economic stimulus for induced investments in Victoria was not assessed.

The economic stimulus calculation method used is captured in Appendix 2.

iii. Telecommunications services

Marinus Link could also bring about revenues by providing fibre-optic broadband services to telecommunications service providers. The potential economic benefit has not yet been investigated.

6.4.1. Quantification of wider economic benefits

The wider economic benefits resulting from items i and ii above have been quantified for both 600 MW and 1200 MW interconnector options. They are presented in Table 12. The total estimated economic stimulus that 1200 MW Marinus Link could bring during the construction and operation phases, in Victoria, is about $1 billion for a 600 MW link, or $2 billion for a 1200 MW link. In Tasmania, construction and operation of Marinus Link is estimated to provide economic stimulus of over $600 million for a 600 MW link, or $1.3 billion for the 1200 MW option. The induced investment in Tasmania could be worth an additional $3.7 billion, noting this is reliant on external investment.

Table 13 presents the estimated number of direct and indirect jobs created during the peak of construction of Marinus Link. In Victoria, the 600 MW link is expected to generate more than 900 direct and indirect jobs. More than 500 direct and indirect jobs would be generated in Tasmania. The greater overland transmission distance in Victoria compared with Tasmania is the reason for more Victorian job creation.

[115] The induced renewable generation is expected to be incrementally installed with the magnitude and timeframe modelled through the EY market model.

Table 12 Estimated value of additional benefits flowing from 600 MW and 1200 MW Marinus Link options

	Marinus Link				Induced investment	
	Tasmania		Victoria		Tasmania	
	Jobs (job-years)	Value add ($M)	Jobs (job-years)	Value add ($M)	Jobs (job-years)	Value add ($M)
600 MW						
Construction	2501	410	4216	718	6075	995
Operations	1224	235	1409	279	3734	537
Total	3725	645	5625	997	9809	1532
1200 MW[116]						
Construction	4206	689	7558	1287	13,513	2213
Operations	3366	632	3870	750	10,675	1535
Total	7572	1321	11,428	2037	24,188	3748

Table 13 Estimated number of jobs during peak of construction of Marinus Link

	Tasmania			Victoria		
	Direct	Indirect	Total	Direct	Indirect	Total
600 MW Marinus Link	111	434	545	151	807	958
1200 MW Marinus Link	196	767	963	281	1501	1782

6.5. Role for governments

As discussed above the delivery of Marinus Link will create economic benefits beyond the electricity market. In recognition of these benefits, governments may wish to contribute towards the cost of developing the project.

This consideration is most pertinent to the regulated model, which presently requires the project's economic assessment to be performed under an electricity market-centred assessment framework (as discussed in Chapter 9).

[116] Appendix 2 presents results for the 1200 MW link in both the neutral case and the high emissions reduction sensitivity (called "EC90" in Appendix 2). The figures in the table are based on the high emissions reduction target sensitivity.

The provision of a government grant would reduce the amount of cost that needs to be recovered from electricity customers. For a regulated model, such a contribution is compatible with the RIT-T[117].

Government funding could also be applicable in a merchant or hybrid model, where a government contribution could recognise community benefits and may improve the market appeal and financeability of Marinus Link and/or support lower electricity price outcomes.

6.6. Regulatory framework review

This section describes the context within which the regulated assessment framework is being investigated for potential reform.

In recognition of the concerns regarding the current regulatory framework for delivering transmission investment, a review was commenced by the AEMC[118] at the request of the Council of Australian Governments Energy Council[119] in September 2018. The aim of this review is to assess drivers that could impact on future transmission and generation investment. It is considering options for actioning the ISP by modifying the RIT-T process for ISP priority projects as well as looking at other potential problems with the RIT-T process, treatment of renewable energy zones and whether storage facilities should pay transmission use of system charges.

In addition to the AEMC review, the Council of Australian Governments Energy Security Board, including the AEMC, will be investigating how to make AEMO's ISP an actionable strategic plan. This includes considering strategies for project implementation and investment as well as considering pricing impacts for customers.

This Report's analysis shows that an imbalance between benefits and costs is likely under the existing regulated transmission pricing framework. Marinus Link delivers benefits – largely to mainland NEM regions – however the cost of Marinus Link would predominantly be recovered from customers in Victoria and Tasmania. This is discussed further in Section 9.2.

In the context of the need for NEM regulatory reform and the changing environment in which interconnector projects are assessed, Project Marinus will continue to work closely with regulatory and government stakeholders. Project Marinus is committed to developing funding and pricing frameworks for better allocation of costs based on benefits accrued. For the project to proceed and be supported as a regulated service, customer pricing outcomes that see beneficiaries paying their fair share of costs will need to be achieved.

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[117] In July 2018, the AER released its *draft regulatory investment test for transmission application guidelines*. Section 3.11.1 of the guidelines states that funds that move from any party outside the NEM (for example, government) to a participant could be considered as a reduction in the costs of the option.
[118] AEMC, *Options paper: Coordination of Generation and Transmission Investment*, September 2018.
[119] Council of Australian Governments, *Energy Security Board Converting the ISP into action*, September 2018.

6.7. Summary of economic analysis findings

The NEM will undergo a profound transition during the next two decades, from a power system dominated by thermal generation to one in which renewable generation sources supply the majority of energy requirements. Inherent in this transformation will be a requirement for increased energy storage and interconnection, to ensure customer demand can be met during the lulls in renewable generation output. This finding is consistent with other studies such as AEMO's ISP.

Our analysis has found that, if constructed, Marinus Link would be a strategic interconnection investment that would provide NEM-wide economic benefits. Marinus Link would reduce the requirement for the installation and operation of peaking plant in mainland NEM regions, as the additional interconnection capacity would allow the substitution of lower marginal cost hydro generation and pumped hydro storage, and other cost-competitive and diversified Tasmanian renewable resources. The additional interconnection capacity provided by Marinus Link would also contribute to increased supply reliability in mainland NEM regions, and provide resilience benefits to both mainland NEM regions and Tasmania in the event of an extended outage of Basslink.

From a Tasmanian perspective, Marinus Link would enable the development of Tasmania's renewable energy and pumped hydro storage potential and bring investment and ongoing employment to regional communities. It can also provide value in the undesirable event of significant loss of Tasmanian load.

For Victoria, Marinus Link could utilise existing transmission infrastructure capacity available from retirement of Hazelwood Power Station and provide a cost-effective mechanism for storage at times of excess Victorian renewable energy. Marinus Link would bring investment and ongoing employment to the Latrobe Valley.

The analysis has shown that, depending on input assumptions, there are significant differences in the potential economic worth of Marinus Link. This variance is in the order of several hundred million dollars, in both the negative and positive direction. Marinus Link has the greatest economic worth (of $490 million for 600 MW capacity, and $480 million for 1200 MW capacity) in the case when coal-fired generation plant retires earlier than its assumed design life. The modelling showed that a high emissions reduction target would cause emissions intensive coal-fired generation to retire early, and there are other factors that were not modelled which could also have the same effect. While the timing of coal-fired generation plant retirement is subject to considerable uncertainty, these retirements are an inevitable part of the ongoing energy market transformation and will be a key determinant of the economic feasibility of Marinus Link.

This assessment has used conservative preliminary values for some categories of benefits that Marinus Link can deliver. Other categories of benefits have not been quantified in this Initial Feasibility Report. It is likely that further detailed examination of these additional potential benefits will result in an increase in Marinus Link's economic worth.

Given the long time required to implement Marinus Link, and the potential benefits it would offer the NEM, it is prudent to continue the assessment of the project to the Final Feasibility and Business Case Assessment Report stage. This would reduce the lead time to implement Marinus Link in the event of an accelerated transition of the NEM to renewable energy sources.

6.8. Next steps

The detailed work done by TasNetworks will be shared with AEMO to help inform its approach to its national planning work, including development of the next ISP. Revised cost estimates as well as the estimation of additional market benefits will support AEMO's modelling of Marinus Link and an optimised development plan for the NEM.

TasNetworks will also progress the RIT-T process for Marinus Link. Submissions received on the Project Specification Consultation Report and those to be made to this Report will inform the approach and analysis to produce the Project Assessment Draft Report for Marinus Link.

The economic modelling will be updated with the latest input assumptions and forecasts and TasNetworks will consider whether different analytical methods should be used to quantify power system security and competition benefits. More detailed calculations of additional benefits will be undertaken for which preliminary values were used, notably the reduction in ancillary services costs, energy security benefits, and the avoided costs of future network expansion.

The results presented in the current study are a series of sensitivity analyses. The analysis was carried out using a cause-and-effect model of a number of different input assumptions, with no attempt to quantify the probability of their occurrence. However, the RIT-T requires market benefit analysis to be undertaken under different internally consistent scenarios, and the resulting net NEM benefits to be probabilistically weighted. A key part of the analysis will be to develop relevant scenarios to support the next stages of RIT-T assessment.

Stakeholder feedback from the Project Specification Consultation Report has drawn TasNetworks' attention to some facets of scenario development[120] and benefits assessment not previously considered. TasNetworks will continue to engage with stakeholders during the course of the RIT-T assessment.

TasNetworks will continue to engage with policy makers, regulators and market bodies as they refine the regulatory and investment frameworks in a transforming NEM.

[120] e.g. Tasmania's hydrogen export potential and its impact on electricity demand.

7. Project plan and cost

Key messages

Project Marinus is considering a link with capacity of 600 MW or 1200 MW. This would see delivery of an interconnector with a single 600 MW link or a 1200 MW interconnector, delivered in two 600 MW stages.

Marinus Link is estimated to have a capital cost of approximately $1.3 - $1.7 billion for a 600 MW capacity interconnector and approximately $1.9 - $3.1 billion for a 1200 MW capacity interconnector.

If Marinus Link proceeds, the project would consist of four phases as shown in the figure below. Each phase comprises multiple activities that are to be completed and triggers to be satisfied to enable progression to the subsequent project phase.

This chapter has the following major objectives:

- defining an initial project timeline for Marinus Link project;
- outlining the estimated cost of Marinus Link;
- identifying risks that may affect the project's timing; and
- detailing the project cost methodology.

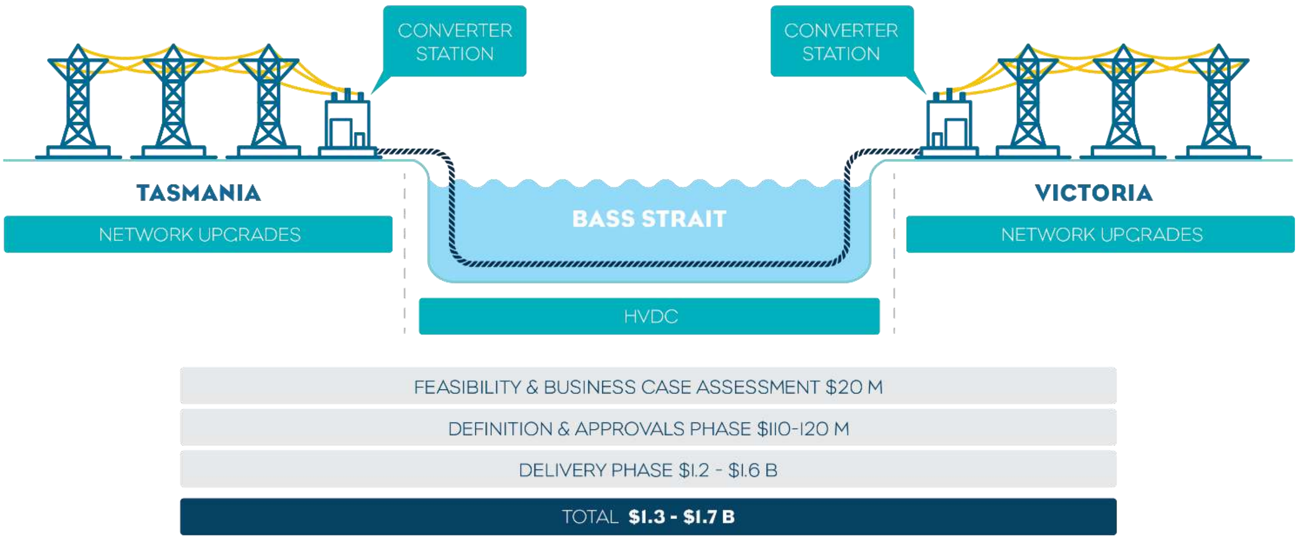
Together, these objectives support project milestones being met within targeted timeframes and budgets.

This Report outlines the progress made in carrying out the first phase of the project, the Feasibility and Business Case Assessment phase. As the project evolves, the timeline, forecast costs and activities undertaken in each phase will be refined further. The phase durations and forecast cost will vary depending on whether the 600 MW or 1200 MW option is adopted; this is particularly the case in terms of project delivery, as discussed in Chapter 3.

An initial cost estimate of $1.1 billion[121] for the 600 MW link was produced in June 2016 as part of the Tamblyn study. In July 2018, TasNetworks released a Project Specification Consultation Report for Marinus Link[122], revising both the scope and cost estimate. This revision was due to the inclusion of some electricity network upgrades in Victoria and Tasmania to support increased electricity flows as well as reconsideration of the base high voltage direct current (**HVDC**) cable costs. For this Report the cost estimate has been further refined with estimates provided by equipment suppliers and engineers, and considering favourable routes. TasNetworks has also considered learnings from the Basslink experience and recent international interconnectors.

An overview of the main cost components for a 600 MW Marinus Link is presented in Figure 21. The cost components for a 1200 MW Marinus Link (assuming two 600 MW stages) are presented in Figure 22.

Figure 21 Project Marinus initial cost estimate for 600 MW interconnector[123]



* Based on an initial conceptual solution of a 600MW HVDC subsea cable.
* This estimate includes a 'contingency' and 'level of accuracy' allowance consistent with the conceptual nature of the feasibility phase of the project.
* The final cost will be impacted by the final technical solution, approval requirements, foreign exchange, commodity prices and equipment costs.

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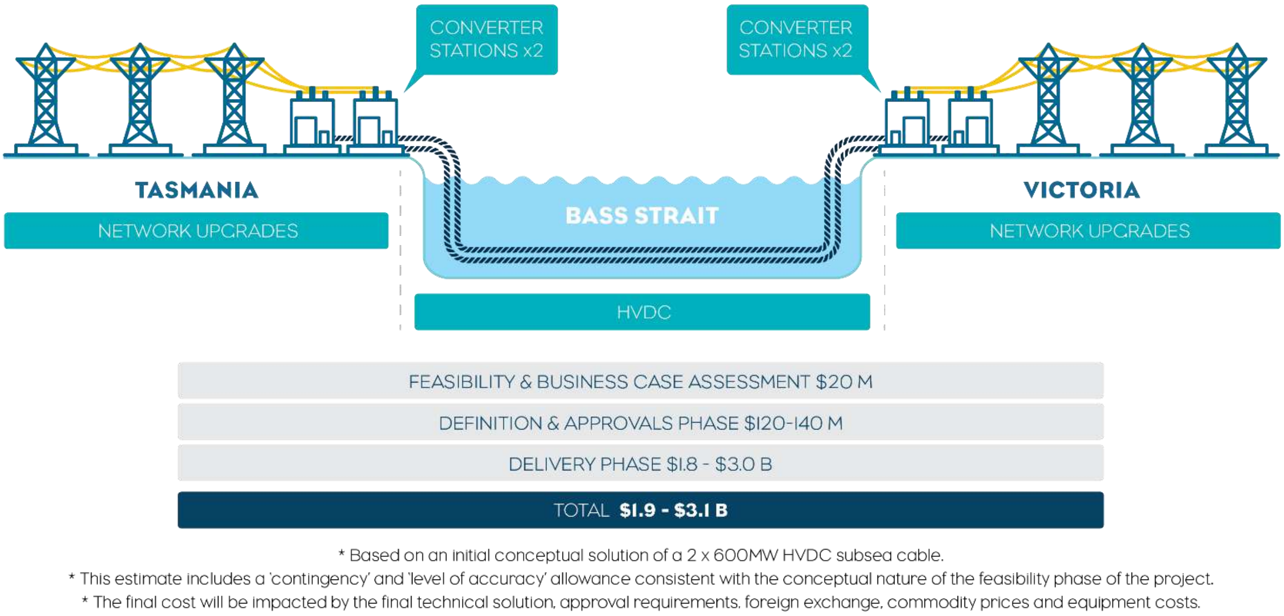
[121] In 2016 dollars.
[122] The Project Specification Consultation Report, discussed in greater detail in Chapter 6, represents the first stage in the RIT-T.
[123] May not add up due to rounding.

Figure 22 Project Marinus initial cost estimate for 1200 MW interconnector (assuming two 600 MW stages)[124]



Marinus Link is estimated to have a capital cost of approximately:

- $1.3 - $1.7 billion for a 600 MW capacity interconnector; and
- $1.9 - $3.1 billion for a 1200 MW capacity interconnector (assuming a staged delivery of two 600 MW stages).

These estimates reflect both the cost to construct the interconnector, as well as some of the associated electricity network upgrades needed to support greater interconnection between Tasmania and Victoria. These cost estimates exclude Tasmanian network upgrades from Palmerston to Sheffield, with this corridor identified by TasNetworks in the 2019-24 Revised Revenue Proposal as a contingent project which may be separately progressed as a result of increased renewable generation.

The Final Feasibility and Business Case Assessment Report is forecast to be released in December 2019. It will further refine the project plan and high-level cost estimates, reflecting the development of the project as it undergoes further analysis.

Details of Marinus Link's initial project plan and cost estimate are provided in the following sections:

- 7.1 Feasibility and Business Case Assessment phase – describes the key tasks of the project phase and the estimated cost.

[124] May not add up due to rounding.

- 7.2 Definition and Approvals phase – explains the purpose, duration and estimated cost of the project phase as well as the key project milestone critical to progressing to the Delivery phase.
- 7.3 Delivery phase – outlines the purpose, duration and forecast cost of the project phase all of which are contingent on the option selected.
- 7.4 Operations phase – describes the activities that would be expected to be undertaken over the service life of Marinus Link.
- 7.5 Risks and acceleration opportunities – discusses the risks to the project timeline and forecast cost as well as opportunities for accelerated project delivery.
- 7.6 Cost estimation methodology – describes the project estimating methodology utilised to derive the cost estimate.
- 7.7 Cost estimation allowances – explains the contingency and accuracy allowances included as cost estimate components.
- 7.8 Next steps – discusses the future work to be completed.

7.1. Feasibility and Business Case Assessment phase

The purpose of the initial project phase is to determine if Marinus Link is feasible and whether there is likely to be a commercial and financial case to proceed to the Definition and Approvals phase. The phase has been jointly funded by TasNetworks and ARENA as an unregulated activity and is estimated to cost $20 million.

Figure 23 Project phases

The estimated duration of the Feasibility and Business Case Assessment phase is two years. The project is currently mid-way through this phase having commenced in December 2017. Based on work done to date, the key findings in this report support continuation of this work in 2019. The major reports to be delivered as part of this phase include the:

- Project Specification Consultation Report: the initial step in the RIT-T process, which was released in July 2018;
- Initial Feasibility Report: this Report, published in December 2018;
- Project Assessment Draft Report: the second step in the RIT-T process, forecast to be released mid 2019; and

- Project Assessment Conclusions Report: the final RIT-T report, forecast to be released in December 2019; and
- Final Feasibility and Business Case Assessment Report, forecast to be released in December 2019.

Several activities will be undertaken prior to the completion of the Feasibility and Business Case Assessment phase in December 2019. A summary description of some of these key activities and their related tasks is provided in Table 14.

Table 14 Activities for the Feasibility and Business Case Assessment phase

Assessment activity	Tasks
Economic feasibility	• Economic modelling to reflect the latest developments of the NEM (including generator, customer and transmission network developments) • Address stakeholder submissions on Project Specification Consultation Report (RIT-T) and this Report
Technical feasibility	• Provide input to AEMO's future ISP work • Complete power control system integration modelling utilising the real time simulator[125] • Understand supplier technical offerings, characteristics and delivery timelines
Environment and land use planning	• Perform environmental surveys on the identified interconnector route options • Identify and secure sites that are critical to the project's development • Commence referrals process
Stakeholder and community engagement	• Analyse and integrate stakeholder feedback on the Initial Feasibility Report • Continued stakeholder and community engagement activities
Project plan and cost	• Refine project timeline estimates based on engagement with suppliers and contractors

[125] The real time simulator is utilised to assess the impact of interconnector design options on the power system. The simulator enables highly accurate forecasting and modelling of power system components in real time.

Assessment activity	Tasks
	• Establish a project delivery strategy • Progress a contracting and procurement strategy • Establish a commercial framework for undertaking the Definition and Approvals Phase[126] • Determine the funding arrangements which will enable the Definition and Approvals Phase to proceed, should the Final Feasibility and Business Case Assessment prove merit • Engage further with suppliers, contractors and transmission network service providers to enable a project cost estimate revision
Ownership	• Sound the market to assess potential models and partners • Perform financial analysis and modelling for the identified ownership models • Identify appropriate ownership structure(s) throughout the project lifecycle
Project cost recovery and pricing options	• Identify the preferred service model under which Marinus Link should be developed • Consider whether the project is likely to generate revenue sufficient to recover capital and operating costs • Work with policy makers, regulators and market bodies to achieve alignment between customers who pay for Marinus Link, and customers who benefit from it • Investigate new interconnector funding and pricing measures that recognise national benefits and see beneficiaries paying their fair share of costs

Subject to the outcomes of the Final Feasibility and Business Case Assessment Report, and securing necessary funding, a more detailed Definition and Approvals phase will follow.

[126] This task will involve determining (subject to approval to proceed) whether TasNetworks or TasNetworks in partnership with another entity will undertake the Definition and Approvals phase. Shareholder agreement for TasNetworks' involvement in this phase would be required.

7.2. Definition and Approvals phase

The purpose of the Definition and Approvals phase is to prepare all assessment and information, including project definition and development activities, to support a final investment decision. At that point, a decision will be made to confirm whether to proceed with delivery of Marinus Link. The Definition and Approvals phase activities are estimated to commence in early 2020 and take up to 2 years. The estimated costs of the phase for the two options being considered in this Report have been estimated including contingency and accuracy allowance. The costs are:

- $110 to $120 million for the 600 MW option; and
- $120 to $140 million for the 1200 MW option (assuming two 600 MW stages).

Figure 24 Project phases

The Definition and Approvals phase prepares Marinus Link for a potential final investment decision. Reaching this objective requires successful completion of:

- land use planning and environmental approvals;
- technical design and specification;
- access to land and easements;
- assessment of revenue certainty; and
- financing and commercial arrangements.

Obtaining land use planning and environmental approvals is a key project milestone and critical to progressing to the Delivery phase. Currently the costs for environmental approvals have been estimated at a high-level and are subject to change. Geotechnical and subsea conditions have not yet been surveyed, with the outcomes of these surveys used to further refine the project design and cost estimate.

The technical design components of the Definition and Approvals phase include the interconnector cable, converter stations and electricity network upgrade works. Design requirements are necessary to allow equipment manufacturers and installers to provide refined quotations used to update the project cost.

Land procurement and easement rights will be needed in Tasmania and Victoria, with initial estimates included in the Definition and Approvals phase cost estimate. Costs associated with securing land and easements could be incurred in earlier and/or later project phases.

The activities required to achieve sufficient revenue certainty will depend on the service model adopted. Service model options are discussed in more detail in the project cost recovery and pricing options chapter.

In order to proceed with a final investment decision, financing and commercial arrangements necessary to support the delivery and operation of Marinus Link will be needed. This includes preparation of all major contractual arrangements ready for execution. The completion of the Definition and Approvals phase will deliver an updated and robust project plan and cost estimate supporting a final decision to proceed, or not proceed, with the investment.

The Definition and Approvals phase includes the completion of activities relating to the following described in Table 15.

Table 15 Activities for the Definition and Approvals phase

Assessment activity	Tasks
Establish future revenue stream	• Pass the RIT-T (or alternate NEM regulatory approvals as necessary) and revenue determination process for Marinus Link and/or supporting transmission upgrades[127] • Reach agreements to provide services under merchant or hybrid service models, if these are progressed • Assess and manage customer pricing outcomes, which may involve Government contributions and/or development of changed pricing arrangements
Technical and engineering design	• Perform detailed land and sea surveys to enable the detailed design and tendering of lines and cable • Engage with HVDC suppliers to confirm technical integration study results • Design protection systems • Develop tender specifications for equipment supply and installation

[127] If this phase and subsequent phases are to be performed by TasNetworks, then close engagement with the AER on TasNetworks' Revenue Proposal will be required.

Assessment activity	Tasks
	• Agree upon and complete transmission connection agreements and performance standards for Victoria and Tasmania
Environment and land use planning approvals	• Undertake the approvals process mapped out in the initial project phase • Complete detailed environmental surveys and submit the environmental impact assessment • Prepare public consultation materials • Identify and negotiate the purchase of sites and easement rights
Stakeholder and community engagement	• Continue stakeholder and community engagement activities • Provide regular project progress updates to stakeholder groups
Project management	• Project management of the Definition and Approvals phase • Prepare for the subsequent Delivery phase
Financial and commercial definition	• Implement a preferred ownership structure for Marinus Link • Agree upon and finalise funding arrangements, including debt and equity raising as appropriate • Finalise contracting, procurement and insurance strategies • Undertake tenders for contracting and procurement activities • Conclude commercial negotiations with counterparties • Complete the detailed estimate for project cost and delivery timeline • Develop contract management and administration procedures and tools • Update financial analysis and modelling • Prepare financial investment decision documentation

7.3. Delivery phase

Following a final investment decision to proceed, the purpose of the Delivery phase is to execute all contractual arrangements and undertake resulting activities to manufacture, construct, install and commission Marinus Link. The Delivery phase could commence in the early 2020s, with a duration contingent on the option selected. Estimated duration is:

- around 4 years for delivery of a 600 MW option; and
- for the 1200 MW option (assuming two 600 MW stages), approximately 4 years for delivery of the initial 600 MW interconnector capacity plus an additional forecast 2 to 3 years for delivery of the subsequent 600 MW.

Delivery of a 1200 MW link is likely to take longer than the 600 MW link option; with timing dependent on factors such as technical design and supplier and material availability. A 1200 MW delivery timeline has been developed assuming two 600 MW stages.

Figure 25 Project phases

The largest component of the project cost estimate relates to the Delivery phase. The estimated costs, including a contingency and accuracy allowance, for the two options being considered in this Report are:

- $1.2 to $1.6 billion for the 600 MW option; and
- $1.8 to $3.0 billion for the 1200 MW option (assuming two 600 MW stages).

The Delivery phase cost estimates include some transmission network costs that may be funded separately to Marinus Link's investment decision. Telecommunications assets represent a very small incremental cost in terms of overall delivery of Marinus Link.

The main procurement items relate to the interconnector cable and converter stations, as well as the materials and equipment required to support electricity network upgrades in Tasmania and Victoria. These cost estimates are sensitive to variations in foreign exchange rates, commodity prices and the global interconnector marketplace.

Manufacturing and installation of the undersea cable is a significant construction cost during the Delivery phase, as well as the converter stations and electricity network upgrades. These cost estimates are contingent on alignment between construction and procurement timelines. Fluctuations in costs may occur due to activities in the global interconnector marketplace. For example, the availability of cable manufacturing slots and cable laying ships may result in cost changes.

The Delivery phase includes the completion of activities described in Table 16.

Table 16 Activities for the Delivery phase

Assessment activity	Tasks
Technical and engineering	• Establish protection schemes (as necessary) • Finalise design • Connect to the Tasmanian and Victorian transmission networks • Commission and acceptance test the end-to-end system
Procurement	• Implement the project insurance strategy • Acquire any remaining required sites and easements in Tasmania and Victoria • Execute contracts for the manufacture of the HVDC cable for subsea and land-based segments between transition stations • Execute contracts for the construction and installation and commissioning of: ○ Transition stations ○ HVDC cable for subsea and land segments between transition stations ○ Converter stations ○ Transmission lines and structures
Financial and commercial	• Implement the requirements arising from revenue determination processes (as necessary) • Financing and revenue recovery planning • Execute service, funding and supporting commercial agreements
Environment and land use planning approvals	• Put into effect any requirements arising from the environmental approval processes

Assessment activity	Tasks
Training and contingency planning	• Put into place training activities to support ongoing operations and maintenance of Marinus Link including contingency planning and incident response processes
Project Management	• Project management of the Delivery phase • Preparation and handover to the subsequent Operations phase

At the end of the Delivery phase, Marinus Link would transition to the Operations phase. This will be contingent upon the successful completion of commissioning and testing activities.

What needs to happen to deliver Marinus Link by the mid-2020s

Delivery of the first stage of Marinus Link by the mid-2020s is contingent on smooth progression from one project phase to the next. For this to happen, funding and approval to proceed to each subsequent project phase is needed ahead of the forecast start date for that phase. This is particularly important for the Definition and Approvals Phase where resources must be available to undertake necessary preparatory work and progress a number of long lead-time items.

To proceed to the Definition and Approvals phase requires:

- funding commitment to preparation activities to plan and secure resources required to be able to move directly into the Definition and Approvals Phase; and
- confirmation of a positive feasibility and business case assessment and funding commitment for Definition and Approvals phase activities.

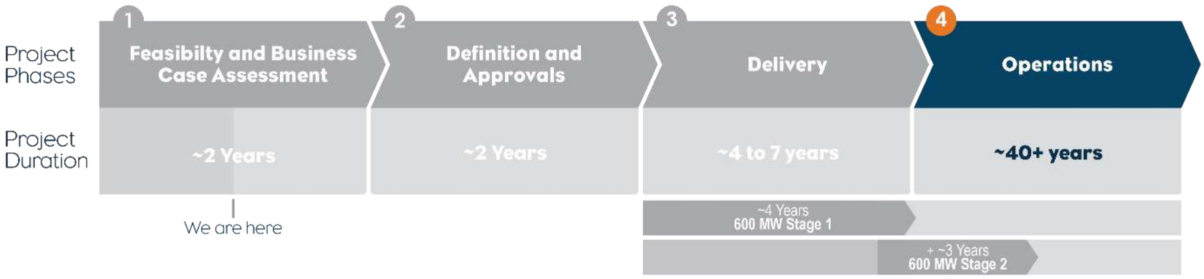
To proceed to the Delivery phase requires confirmation of the business case assessment in the form of a Final Investment Decision, after successful completion of:

- land use planning and environmental approvals;
- technical design and specification;
- access to land and easements;
- assessment of revenue certainty; and
- appropriate financing and commercial arrangements.

7.4. Operations phase

The purpose of the Operations phase is to operate and maintain Marinus Link within its technical design limits ensuring maximum utility and benefit is derived from the link. This phase could commence as early as the mid-2020s. Once the link is in service, an interconnector would move into the Operations phase, with an expected service life of at least 40 years.

Figure 26 Project phases



Operations and maintenance costs have been revised from the estimate included in the Project Specification Consultation Report. This revision is based on an improved understanding of the technical aspects of the two options being considered. The estimated costs for this phase for the two options being considered in this Report are:

- $20 million per annum for the 600 MW option; and
- $30 million per annum for the 1200 MW option (assuming two 600 MW stages).

These cost estimates are indicative and will be refined as the Final Feasibility and Business Case Assessment progresses.

The Operations phase includes the completion of activities as described in Table 17.

Table 17 Activities for the Operations phase

Assessment activity	Tasks
Maintenance	• Perform routine and scheduled maintenance of the cable and converter stations and strategic spares • Maintain operating systems and manage data requirements in line with the requirements of interconnector asset operators
Operations	• Manage activities to support revenue recovery – under regulated and/or commercial service framework established • Control and manage Marinus Link within defined operating conditions, including responding to changing environmental conditions, energy transfer requirements and compliance with operational limits • Coordinate with generators and relevant transmission network service providers on Marinus Link capacity and condition to enable efficient operation and dispatch management • Manage equipment and staffing for Marinus Link's day-to-day operation, including ongoing training • Contractual management and business operations, including to meet NEM and company compliance obligations • Incident response and preparation and insurance arrangements

7.5. Risks and acceleration opportunities

A project of this scale and significance would have a number of risks to manage throughout the lifecycle. Project plan and cost risks associated with each of the project's phases have been identified as part of this Report and will require management to mitigate their impact. TasNetworks could undertake some – or all – of these project phases. The work may also be progressed by other parties, in partnership with TasNetworks or independent of TasNetworks.

At this point several factors have been identified that may impact the project plan and cost. These include key factors affecting the scope, timing and cost of construction, such as:

- geotechnical and subsea conditions which have not yet been surveyed – results will assist to refine the design of the technical solution and cost estimate;
- environmental regulatory requirements which have been estimated at a high-level and will be adjusted following completion of the required environmental assessments;

- availability of cable manufacturing slots and cable laying ships which is uncertain especially given the current activity in the global interconnector market; and
- prevailing weather conditions that may impact the Delivery phase of the project, particularly the installation of the subsea cable.

Risk management will be a critical factor in ensuring adherence to the project plan and budget through all project phases. Throughout its lifecycle Marinus Link will require a comprehensive and robust project management methodology, and supporting risk management framework.

Funding support for acceleration

The present project plan scope and timing assumes a full NEM regulatory investment test assessment under the present Rules, with provision of regulated services a plausible model for Marinus Link. It also assumes that funding and approval to proceed from one project phase to the next project phase is achieved well ahead of the start date for each phase, so that resources are available to undertake necessary work. This early commitment to funding for each phase therefore supports timely progress of the project.

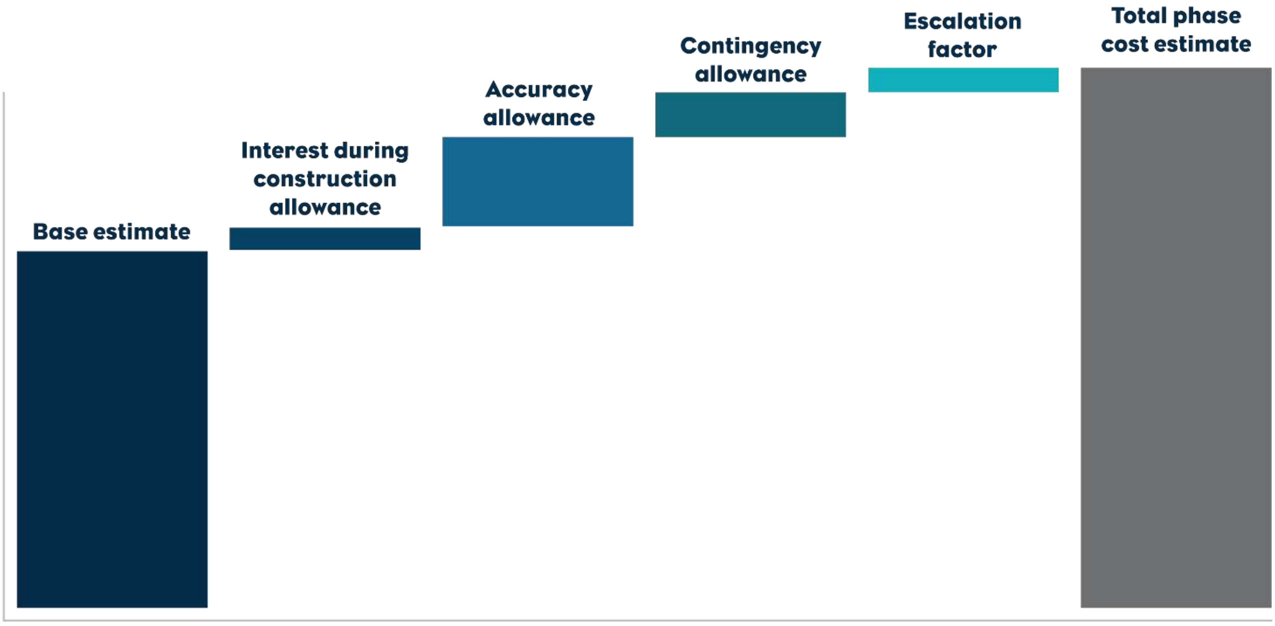
The economic analysis shows that under some circumstances, Marinus Link could provide positive economic worth from the 2020s. To support the possibility of delivery by the mid-2020s, work should progress to secure funding for the Definition and Approvals phase.

Early commitment to fund the Definition and Approvals phase would allow commencement of resource planning and procurement to support long lead time items such as technical design, environment and land use planning approvals and acquisition of land and easements. It could also allow some different sequencing of activities to reduce lifecycle costs and/or accelerate the delivery of Marinus Link, should this be required. This would support a ‘shovel ready’ project, able to move more quickly to the Delivery phase when required.

7.6. Cost estimation methodology

In developing electricity transmission network projects, TasNetworks adopts a consistent project estimating methodology resulting in dependable project outcomes. This methodology aligns with the approach taken for all significant regulated electricity network investments, which the AER reviews. The project cost estimates for Marinus Link presented in this Report are consistent with this approach. An overview of the cost estimation approach is provided in Figure 27.

Figure 27 Project Marinus cost estimation methodology



An initial base estimate is produced, typically reflecting cost data of similar projects that have recently been collected and updated. This base estimate forms the basis for subsequent building block items that allow for estimate adjustment allowances and variant factors.

An interest during construction allowance represents the next building block in the cost estimate. It accounts for the cost of capital during the project design and construction.

As part of the estimating process, TasNetworks applies an accuracy allowance building block to reflect the level of project definition available at the time[128].

A further building block relating to the project's contingent risks is allowed for in the estimate. The contingency allowance is estimated relative to the base estimate. Accordingly, when the base estimate is revised the contingency estimate is also revised.

The final building block, input cost escalation factors, is added to account for expected escalation in the costs of labour, materials and land over the period of the project. Escalation is based on forecasts and reflects the current view of future events, such as market conditions.

The cumulative result of this building block approach yields a total cost estimate for each phase.

[128] For example, progressing from a level 1 estimate to a level 2 estimate results in a refinement of the accuracy allowance.

7.7. Cost estimation allowances

The cost estimate outlined in this Report includes a contingency and an accuracy allowance, reflective of the current stage of the project. The percentage applied to the estimate for the accuracy allowance will be reduced as more detailed project specification becomes available. At this stage, varied accuracy and contingency percentages have been applied to cost components, reflective of the level of detail available and the associated risk.

Contingency allowance

A contingency allowance is a provision for a risk that might occur. Contingency risks are limited to unplanned events that pose a threat to the project in terms of their perceived likelihood and that may materially impact project costs. Typically, these risks are mitigated by risk management, which may include insurance arrangements. However, where a risk cannot be completely removed by applying control measures, then a contingency allowance is normally applied.

For Marinus Link, contingency risks may include:

- stakeholder and planning issues, including delays in environmental planning and approvals;
- occurrence of an unplanned event such as extreme weather; and
- delivery delays due to issues with manufacturing or installation of equipment.

Accuracy allowance

Accuracy allowances are a measure of the certainty around a project cost estimate. For an infrastructure project like Marinus Link, it is typical to include a larger accuracy allowance at early project stages, for instance during a feasibility study. As the technical aspects become more certain and the level of technical specification increase, the level of accuracy allowance is reduced. For Marinus Link, the accuracy allowance would decrease as iterations are undertaken for project cost estimates in the Definition and Approvals phase.

7.8. Next steps

The Final Feasibility and Business Case Assessment Report forecast to be completed during 2019 will include a revised project plan and cost estimate. As the level of project definition improves the level of uncertainty will decrease and the project plan clarity and cost estimate accuracy will improve.

Work will continue in 2019 to progress the analysis in this report, and undertake additional engagement and analysis. This will include detailed consideration of the service, funding and pricing models needed to inform the Final Feasibility and Business Case Assessment Report.

Work should also progress to secure funding for the Definition and Approvals phase to allow long lead time activities, such as technical design and land use planning approvals to be undertaken. This would support a 'shovel ready' project, able to move more quickly to the delivery phase when required. Work should also continue to secure land and easement rights, to preserve corridors for future Bass Strait interconnection.

8. Ownership models

Key message

A high level analysis of ownership models has been undertaken. The Final Feasibility and Business Case Assessment Report will include a more detailed assessment of the ownership and related financing options outlined in this chapter.

This chapter provides a description of the ownership, operator, developer and financing options for Marinus Link. These models will be assessed as part of the Final Feasibility and Business Case Assessment during 2019.

The three potential ownership models are described in Figure 28.

Figure 28 Potential Marinus Link ownership models

Public ownership	Public - private ownership	Private ownership
Public entities such as: - Tasmanian Government Victorian Government - Commonwealth Government - Publicly owned businesses such as a NSP or other energy industry participants	- Includes a combination of public and private entities	Private investors such as: - Infrastructure/investment funds - Financial institutions - Privately owned NSPs or other energy industry participants - Equipment suppliers and manufacturers

The Tamblyn study reviewed a range of possible ownership models for a second Bass Strait interconnector, which includes those described in Figure 28.

The Tamblyn study found that multiple ownership options should be considered for further investigation, with each presenting their own merits relating to market appetite and risk. Our initial assessment is that Marinus Link and Basslink can successfully operate and provide value across a range of ownership and service models. However, there is further work to be undertaken to better understand the most appropriate ownership and service model to be pursued for Marinus Link. The service model chosen (for example, regulated, merchant or hybrid) will impact investor interest and risk perceptions when contemplating ownership, operations and/or financing. Therefore, a critical assessment of the energy and commercial markets will be undertaken as part of the Final Feasibility and Business Case Assessment during 2019.

This chapter contains the following sections:

- 8.1 Project developer – describes the considerations for the interconnector's developer
- 8.2 Asset owner – explains the ownership model options for Marinus Link.
- 8.3 Interconnector operator – outlines the potential operators for the interconnector.
- 8.4 Project funding – describes possible funding options for Marinus Link.
- 8.5 Next steps – discusses the future work to be completed.

The responsibility for project development, ownership and operation will be determined at a later stage during the project's Definition and Approvals phase. The role of project developer, owner and/or operator for Marinus Link may rest with TasNetworks or other parties.

8.1. Project developer

The role of project developer is critical to the successful completion of major infrastructure projects, such as Marinus Link. A developer takes the project forward and is responsible for amongst other things performing detailed design work and construction of the project following a Final Investment Decision[129].

Central to the successful development of infrastructure projects is management and allocation of delivery risks between the owner and the developer (with due regard to financiers' requirements as well). As interconnectors are complex, from technical, construction and commercial perspectives, the role of project developer would require a party with suitable expertise. For Marinus Link, the role of project developer can be performed by one or a consortium of parties.

8.2. Asset owner

Ownership of Marinus Link relates to how the interconnector may be utilised and how it achieves a return on the capital outlaid to develop it and recover operating costs. An asset owner is an entity (or entities) that possess the right to receive the revenue generated from operating the asset, and the right to sell the asset, having used capital or incurred a liability (such as debt) to acquire it.

This section describes the possible asset ownership models for Marinus Link, which includes public, public-private and private ownership models. These will be further investigated in 2019.

[129] Further details of this process are outlined in Chapter 7 Project plan and cost.

8.2.1. Public ownership

Public ownership, alternatively known as government or state ownership, refers to an asset that is owned by a government or a government-owned organisation on the behalf of its constituents. A publicly owned Marinus Link model will be investigated as part of the subsequent stage of the assessment during 2019.

For example, Marinus Link may be owned and operated by TasNetworks, wholly owned by the State of Tasmania. This type of model may be beneficial in ensuring community interests are met, as a government can use government directions to consider broader community objectives beyond a business' own commercial interests.

Public ownership could also include Commonwealth Government ownership, or ownership contribution, to support the timely development of Marinus Link and realisation of forecast strategic benefits for customers. The Commonwealth Government's purchase of full interest in Snowy Hydro, including the potential Snowy 2.0 development, represents a recent example of the Commonwealth Government investing equity in nationally significant infrastructure to support overall improved NEM outcomes.

Government ownership may only be sought for a period of time. For example, following successful commissioning and operations of Marinus Link, and demonstration of commercial benefits, ownership could be transferred in part or in full to private investors.

8.2.2. Private ownership

Private ownership refers to an asset that is owned by one or more private entities.

Potential private investors include infrastructure/investment funds, privately owned network service providers, other energy industry participants and equipment suppliers and manufacturers. Basslink is currently owned by Keppel Infrastructure Trust, a private company listed on the Singapore Stock Exchange.

8.2.3. Public-private ownership

Public-private ownership refers to an asset that is owned in partnership between two or more public and private entities. It is a model commonly employed for large infrastructure projects in Australia and overseas. A public-private ownership can be beneficial as the project risks can be shared between two or more entities. These arrangements also provide the opportunity for the public partner to access expertise and funds to support the overall delivery of the project.

Three possible public-private ownership options are discussed in the following sections relating to a partnership between government and either: network service providers, energy industry participants, and private investors. This does not represent an exhaustive list of options, and there may be combinations of the options below.

Option 1: Public body and private network service provider

One possible type of public-private ownership model for Marinus Link is between a public body and a privately owned network service provider.

Option 2: Public body and private energy industry organisations

An alternate public-private ownership option for Marinus Link is an equity arrangement between a public body and privately owned organisation that is active in the energy industry. Such private bodies could include generation and/or retail participants (although this may be constrained by ring-fencing and ACCC clearance requirements[130]), and/or other participants in the supply chain for the energy industry. Major industrial electricity customers, renewable energy project developers, and equipment manufacturers directly or indirectly involved in the development of interconnectors, may have interest a public-private partnership.

Option 3: Public body and private non-energy market participants

A public-private partnership with non-energy market private investors is another option for asset ownership of Marinus Link. Such private investors may include financial institutions, infrastructure funds and/or other international investors.

Ownership of electricity infrastructure as partnerships between public bodies and private investors is common in Australia. For example, in New South Wales, three of the State's network service providers have equity arrangements between private investors and the New South Wales Government[131].

Some potential investors may only take an equity share in Marinus Link following its commissioning and where there is confidence that an appropriate operator is in place.

8.3. Interconnector operator

The role of the interconnector operator is to ensure safe and reliable electricity transmission. An asset operator is the party responsible for the day-to-day operations and maintenance and may also manage availability of the interconnector to the NEM. For Marinus Link, this would involve interacting with AEMO as market operator, and AEMO, AusNet Services and TasNetworks as transmission network service providers in Victoria and Tasmania.

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[130] To date, due to Australian Competition and Consumer Commission (**ACCC**) concerns, co-ownership of electricity generation, retail and transmission assets has occurred to a very limited extent in the NEM. Acquisition of an interest in transmission assets by either a generator or retailer would be reviewable by the ACCC under Competition and Consumer Act 2010. In addition, the current AER Transmission Ring-fencing Guidelines restricts a transmission network service provider from the activities of generation and electricity retail supply.

[131] In this instance, equity arrangement is achieved via the execution of a 99-year lease of the network service provider.

The choice of interconnector operator options can be influenced by the ownership and service model employed. It is possible for one entity to be the owner, a separate entity to be the operator or for both roles to be undertaken under a common ownership model. These options will be further investigated in 2019.

8.4. Project funding

The development of significant infrastructure projects, such as Marinus Link, requires considerable upfront funding to facilitate the development and delivery of the project. For Marinus Link, there are several funding options which will be assessed as part of the Feasibility and Business Case Assessment during 2019.

The type of funding available may depend on the ownership structure and service model employed for Marinus Link. The nature of the owner(s) may also impact the availability and cost of financing. Financing options may include:

- public funding, which could take the form of grant, equity, loan or other assistance from Government;
- project finance, where the project is funded separately to the parent entity, and which could be provided by equity and/or a lending institution or syndicate of lending institutions;
- on-balance sheet finance, such as corporate debt, which could be provided via the project's owner(s) leveraging its existing levels of assets and equity; or
- equity contributions from owner(s), either through existing equity or as a result of additional equity raising.

8.5. Next steps

Work will continue in 2019 to progress the analysis in this Report, and undertake additional engagement and analysis. The Final Feasibility and Business Case Assessment Report will include a more detailed assessment of the ownership and financing options outlined in this chapter. This phase will include the development and application of an assessment framework to evaluate the options and identify ownership arrangements expected to support a positive business case assessment.

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9. Project cost recovery and pricing options

Key message

Where Marinus Link is forecast to deliver a positive net economic benefit, the question of 'who pays' is an important factor to be considered in the investment decision.

TasNetworks will seek service delivery models and project cost recovery options that result in customers only incurring costs that are commensurate with the benefits they receive.

A major infrastructure project will typically incur most of its costs upfront, while the benefits that result from it flow over many years. For a project such as an interconnector, this means that careful consideration needs to be given as to the service model under which the costs are recovered over the project's lifetime.

This chapter aims to outline the service models to recover costs, and some customer pricing outcomes, which may be linked with the funding and service models under which the project is developed and operated.

The service models being considered for project cost recovery, include:

- Regulated model – which allows the project's costs to be recovered through regulated transmission charges incurred by electricity customers.
- Merchant model – which allows for project cost recovery via trading between regional electricity markets and/or via service agreements with counterparties.
- Hybrid models – which allow for an interconnector's transmission capacity, service offerings and cost to be split and recovered under a combination of the regulated and merchant models.

In addition to the electricity transmission services offered by Marinus Link, there are also telecommunication services that can be provided.

The Final Feasibility and Business Case Assessment Report will consider further the service and revenue models of Marinus Link, as well as potential telecommunication services.

Service models and the wholesale energy market impacts

Our analysis shows that Marinus Link could enable substitution of lower cost Tasmanian hydro generation, pumped hydro storage and competitive renewable resources in place of higher cost solutions in mainland NEM regions.

Further interconnection between Tasmania and Victoria may also create a more competitive energy market by offering greater flexibility to the system operator and market participants in how and when power is dispatched and supporting contractual arrangements are structured. This has the potential to result in improved customer outcomes.

There are potential differences in wholesale energy market outcomes between a merchant and regulated link. The Tamblyn study considered these implications at a high level. For example, under a merchant model arrangement, there may be financial incentives for a merchant link owner to reserve capacity, which may decrease the wholesale energy market benefits realised by customers. TasNetworks will continue to explore service model options that may make a merchant link viable, including the potential impacts on wholesale energy price outcomes.

As part of the Feasibility and Business Case assessment for Marinus Link, a RIT-T process has commenced[132]. This process may enable a regulated model to be employed. However, TasNetworks is committed to assessing the range of service models that may best serve the interests of the NEM and the community.

This chapter includes a discussion of potential pricing outcomes under a regulated model, highlighting that under the current pricing framework Tasmanian customers' transmission charges would increase disproportionally as a result of Marinus Link. Under the present regulated pricing model customers in other jurisdictions would benefit from Marinus Link, via lower delivered cost of energy, without having to pay their fair share of the underlying cost of increased interconnection.

Government funding could recognise the broader economic and national benefits of Marinus Link under all models under consideration. Under a regulated model a government grant could be structured to deliver lower transmission charges for customers and more fairly allocate costs and benefits across Australia.

[132] TasNetworks' published a Project Specification Consultation Report, the first step in the RIT-T process, in July 2018.

This chapter is divided into the following sections:

- 9.1 Regulated model – describes the NEM regulatory process including the relationship between the RIT-T, revenue allowances and customer pricing.
- 9.2 Current regulated transmission pricing allocation – outlines interconnector cost allocation and revenue recovery.
- 9.3 Merchant model – describes operations under a merchant model.
- 9.4 Hybrid model – explains the hybrid model which brings together characteristics of both the regulated and merchant models.
- 9.5 Telecommunication services – provides an overview of the state of the market and the opportunity for service provision.
- 9.6 Next steps - discusses the future work to be completed.

9.1. Regulated model

This section explores Marinus Link operated under a regulated model. A regulated model refers to a project whose costs can be recovered via regulated transmission charges incurred by electricity customers.

To establish an interconnector project under the present NEM regulated model, a project is required to undergo a market cost-benefit assessment – the RIT-T. There is a prospect that Marinus Link may successfully pass a RIT-T – including where there are Government contributions to recognise broader regional and national benefits.

The RIT-T process aims to promote efficient investment in electricity services for the long-term interests of consumers of electricity. The assessment is focussed on maximising the net economic benefit across the NEM. The RIT-T process for the project has commenced, with further work on the detailed RIT-T analysis to continue in 2019. Passing the RIT-T allows a transmission network service provider, such as TasNetworks, to earn revenues as determined by the AER[133] through a NEM regulatory determination process. Revenue recovery is based on transmission pricing rules that largely result in project cost recovery determined by customers' use of the network. The transmission pricing process ignores the NEM wide net economic benefits identified through the RIT-T process. The disconnect between the investment assessment and subsequent revenue recovery does not support network charges that are commensurate with the benefits customers receive.

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[133] For a transmission network service provider, passing the RIT-T allows the asset's cost to be included in its regulatory asset base (**RAB**). The RAB for a transmission system owned, controlled or operated by a TNSP is the value of those assets that are used by the transmission network service provider to provide prescribed transmission services, but only to the extent that they are used to provide such services, National Electricity Rules, cl. 6A.6.1.

Under a regulated model, customers bear the risk of Marinus Link not delivering all the forecast benefits. Conversely, greater benefits may be realised than expected, but customers pay no more than the efficient cost determined by the AER. The greater certainty of revenue under a regulated model results in a lower cost of capital, which translates into relatively lower customer charges.

Once operational, a regulated interconnector operates like the rest of the shared transmission network, with energy flowing freely in accordance with plant availability, system constraints and market dispatch. This arrangement utilises the interconnector to minimise the delivered cost of energy for all NEM customers.

Delivered cost of energy

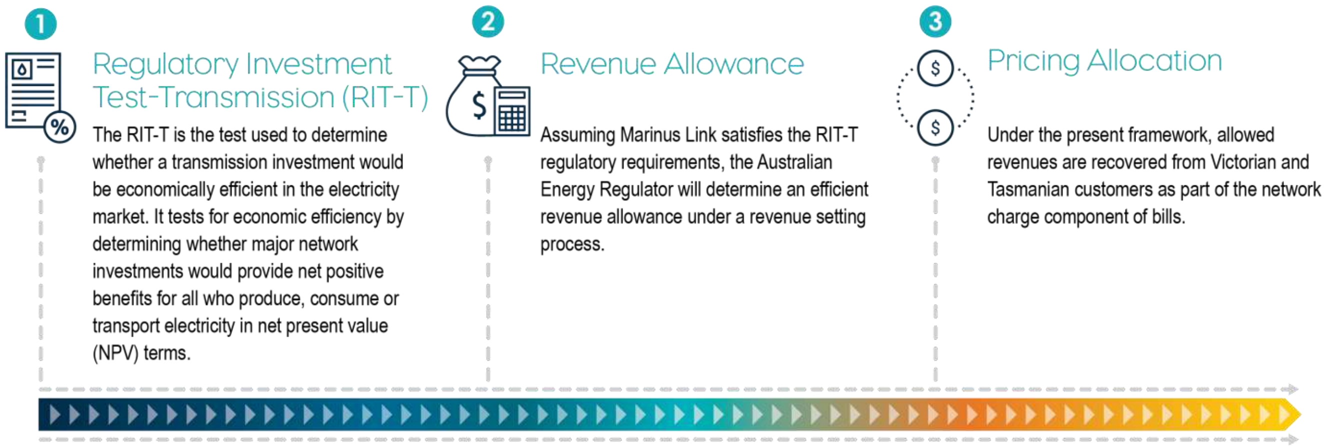
The retail electricity prices paid by customers cover much more than the cost of generating the electricity that customers use.

The delivered cost of energy includes the cost of transporting electricity via the high voltage transmission network and the low voltage poles and wires that make up the distribution network. The delivered cost of energy also includes the cost of energy and ancillary services traded in the wholesale market and the cost to operate the power system and market in real time, retail costs associated with trading and selling electricity to end-users and paying for legislated 'green schemes'.

As interconnectors traverse multiple jurisdictions, the allocation of a project's annual revenue allowance is divided between the jurisdictions. For a regulated Marinus Link, the revenue would be recovered via transmission charges set under the Rules. Charges for Tasmania would be calculated by TasNetworks and for Victoria by AEMO, as the jurisdictional pricing transmission network service providers.

The NEM regulatory process including the relationship between the RIT-T, revenue allowances and customer pricing is outlined in Figure 29 below.

Figure 29 The present NEM regulatory process



9.2. Current regulated transmission pricing allocation

The current NEM regulatory framework determines the revenue entitlement associated with the costs of an interconnection service between the connected states, including costs relating to the assets linking both transmission systems. This includes the converter stations, and land based and subsea high voltage direct current (**HVDC**) cables. In addition to the HVDC assets and converter stations, there may be upgrades to the existing transmission assets in the Tasmanian and Victorian power systems to host the interconnector.

For the two options assessed in this Report, the capital cost estimates for the interconnector are:

- for the 600 MW option, the estimated cost range of $1.3 to $1.7 billion; and
- for the 1200 MW option (assuming two 600 MW stages), the estimated cost range of $1.9 to $3.1 billion.

The following section provides an overview of interconnector cost and revenue recovery.

9.2.1. Interconnector cost allocation and revenue recovery

There are a range of ways that regulated revenues can be allocated between regions and the current NEM Rules framework for apportioning interconnector revenue is not clear-cut. The proportion of interconnector revenue allocated between jurisdictions is subject to an assessment and negotiation process, which may include jurisdictional agreement. Typically revenue for each geographic region reflects the assets located in that region. With an asset crossing Bass Strait, there is scope for different allocation, including by agreement between jurisdictions.

Recovery of the revenue allocation for each NEM region is undertaken according to a TNSP's AER approved pricing methodology. The current pricing framework results in the vast majority of interconnector and transmission shared network revenue allocated to a NEM region being recovered from customers within that region, even where the assets are principally used to move energy to other NEM regions.

The modified load export charge (**MLEC**) enables a charge to be levied on connecting NEM regions (based on inter-regional energy flows); in this case between Tasmania and Victoria. This charge enables some regionally allocated revenue to be recovered from other regions, based on the underlying usage of a region's network by customers in the immediately connected region. However, the transfers under the MLEC only applies to some revenue requirements and are generally minor when compared with total revenue requirements within a region.

As coal-fired generation retires, building Marinus Link supports lower energy cost outcomes for customers in Victoria, New South Wales, Queensland and South Australia. The market model used by EY to calculate the resource cost impact of Marinus Link (refer Chapter 6) also calculates a proxy for the hourly wholesale energy price in each NEM region[134]. The energy price outputs of the model indicate that the majority of the energy price savings delivered by Marinus Link end up being seen by customers in the mainland NEM regions, principally in Victoria and New South Wales, with smaller savings in South Australia and Queensland.

While there are some potential benefits for Tasmanian electricity customers from Marinus Link, in terms of increased energy security and potentially increased competition, the significant energy resource cost savings all flow to customers in the rest of the NEM. However, there is a disconnect between the RIT-T assessment, which considers benefits across the NEM, and the pricing framework to recover the resulting efficient revenues, which applies to each region of the NEM where the assets are constructed and allocated.

The current NEM regulated network pricing framework would lead to higher transmission charges in Tasmania and Victoria. It would not pass on network charges to electricity customers in other regions, who would benefit directly from Marinus Link. Tasmania will see benefits arising from broader economic stimulus from Marinus Link investment, but receive fewer benefits in the energy market. This means the NEM network pricing framework as it currently stands, when applied, will disproportionally disadvantage Tasmanian customers.

Where the project is forecast to deliver a positive net economic benefit, the question of 'who pays' will be highly relevant to the investment decision. Therefore, TasNetworks considers that the link should only proceed as a regulated service if regulated pricing outcomes recognise that Marinus Link benefits are principally to mainland NEM customers. Ways that this could be achieved include:

- contributions from Government, such as grants that recognise national benefits and that directly offset Marinus Link costs allocated to Tasmanian customers; and/or
- modifications the present NEM pricing framework.

TasNetworks will actively work with policy makers, regulators and market bodies to seek appropriate customer pricing outcomes.

[134] The model calculates the hourly energy price proxy based on a combination of short run marginal cost for existing energy sources and long run marginal cost for new energy sources.

9.3. Merchant model

This section explores a Marinus Link operated under a merchant model. A merchant model (or unregulated model) refers to a project that earns its revenues as a result of electricity market participation and/or provision of services to counterparties. Unlike the regulated model – where revenues are earned via regulated network charges – a merchant interconnector earns revenues from electricity markets and/or long-term agreements with other parties[135].

A merchant model does not require an interconnector to satisfy the RIT-T process. Currently, there are six interconnectors across the NEM[136] – only Basslink is operated under a merchant model.

Establishing an interconnector under a merchant model does not prevent it from later changing to a regulated status – provided it is able to pass the RIT-T. This approach has previously been adopted by the Directlink and Murraylink interconnectors[137]. However, once regulated, an interconnector is not able to transition back to a merchant status.

For an interconnector to trade into electricity markets it must first register as a market participant[138] and meet a range of NEM obligations, such as the ability to separately control and meter energy. To earn revenues via market trading, a difference in electricity market prices must be present.

Basslink generates revenue in a similar way to generators in the NEM: by bidding its capacity to deliver energy into the spot market, with the returns largely determined by the price difference and the energy flows between Victoria and Tasmania. An illustrative example of how this revenue is created is provided in Figure 30 below.

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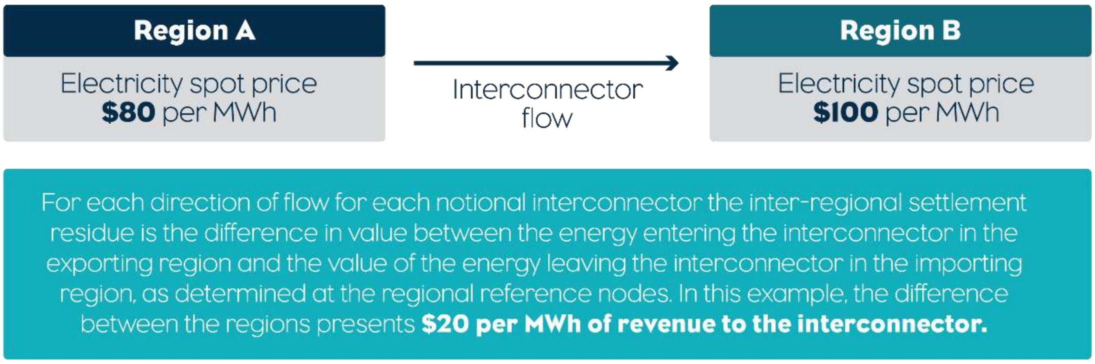
[135] Market-based revenues are received from AEMO as a result of trading in regional markets. Long-term agreements can be struck with market participants, such as retailers or generators, or with governments, to provide services such as access to link capacity or particular ancillary services.

[136] Directlink, Queensland to New South Wales Interconnector (**QNI**), Victoria to New South Wales Interconnector, Basslink, Heywood Interconnector, and Murraylink. AEMO, “Interconnector Capabilities”, 2017.

[137] Merchant operation of Directlink and Murraylink occurred from 2000 to 2006 and 2002 to 2003, respectively. Both interconnectors have since transitioned to a regulated status having satisfied the RIT-T process.

[138] A market participant, or market network service provider, refers to those who provide *network services* in accordance with the National Electricity Rules and who is also registered by AEMO for market participation.

Figure 30 Illustrative example of electricity price arbitrage between regional markets[139]



In addition to provision of electricity, interconnectors are able to earn revenues from the provision of ancillary services for which revenues are received from AEMO. They can also allow other values to be monetised. For example, an agreement could be struck for dispatchable on-demand capacity to support variable renewable output.

To earn revenues under a market-based approach, an interconnector operator bears the relatively high risks linked with the uncertainty of electricity markets. As the project cost is recovered over a period of decades, there can be substantial difficulty finding investors comfortable with such a level of uncertainty. This usually drives the operator to establish (alone or in combination) long-term agreements with market participants.

One form of long-term agreement is to provide interconnector capacity in return for annual payments. Basslink is an example of such an arrangement. A summary of the long-term agreements supporting the merchant Basslink interconnector is provided in Information Box 1.

[139] The difference in pricing between regions is also referred to as settlement residues when considering the MLEC locational component of the regulated model's project cost allocation. Note, figures in this example are exclusive of transmission losses.

Information Box 1: Basslink long-term agreements

At the time of development, two long-term agreements were established regarding Basslink.

The first agreement, Basslink Operations Agreement was between the Tasmanian Government and Basslink. Its focus was to ensure a certain level of availability and performance standards for the interconnector, which is not directly valued by existing electricity markets. It does not, however, comprise any incentive on the economic performance of Basslink.

The second agreement, Basslink Service Agreement, was established between Hydro Tasmania and Basslink. Its purpose is to incentivise Basslink for availability and performance of the link and arbitrage value. It also permits Hydro Tasmania to determine the bid price for Basslink in a trading interval. The Basslink Services Agreement allows the owners of Basslink to swap that market-based revenue for an agreed fixed facility fee, plus performance-related payments.

There may be innovative merchant models beyond those presently anticipated in the NEM, which may present commercial options to support the feasibility of Marinus Link.

9.4. Hybrid model

The hybrid model brings together the characteristics of both the regulated and merchant models.

For this to occur, the project may require dividing of transmission capacity and costs between regulated and merchant portions of the interconnector. This could be achieved in two possible ways, including:

- an interconnector that comprises two physically separate assets (e.g. a 1200 MW link with two 600 MW stages), for which one is established under a regulated and another under a merchant model – which would meet present Rules requirements for separate metering and control; or
- an interconnector that comprises a single set of assets, for which its capacity is split to allow a portion to operate under a regulated and merchant model respectively – which may require a Rule change.

In general terms, a hybrid model could allow greater interconnector capacity to be realised, by underwriting some of the revenue risk through a regulated service, while providing the opportunity for higher returns from a merchant service offering for additional capacity.

This could allow economies of scale from delivering a higher capacity link while allowing the cost recovery risks to be shared between the interconnector operator for the merchant portion and network customers for the regulated portion.

Throughout Europe and the UK regulatory regimes are developing to share the risks associated with development of interconnectors – with new regulated frameworks developed to allow hybrid links. This includes the cap and floor methodology, summarised in Case Study 1.

Case study 1: Nemo Link cap and floor regime

Nemo Link is a subsea interconnector between the United Kingdom and Belgium which will start operating in 2019. It will use a hybrid merchant/regulated model for commercial operation. Under this regime Nemo Link will be subject to a revenue cap, while also receiving protection against downside risks via a floor. To do so, the UK energy regulator (**Ofgem**) and the Belgian energy regulator (**CREG**) determine two values: the floor value and the cap value. The floor value is derived from the efficient costs (asset depreciation, opex, cost of debt). The cap value is derived from the return on equity.

Once a pre-determined availability target has been reached, Nemo Link's operations will generate revenues. The revenues that can be generated have a minimum value (the floor value) and a maximum value (the cap value). If revenues rise above the level defined in the cap payments will be made by Nemo Link to electricity consumers. Alternatively, if revenues fall below the floor level payments are made by electricity consumers, under their network charges, to the interconnector owner. This way, the operator Nemo Link is ensuring base cost recovery while consumers benefit from increased interconnection. Consumers are potentially rewarded by sharing higher than forecast revenues.

At present, there are no interconnectors developed under a hybrid model in Australia. TasNetworks will consider interconnector service models as part of the ongoing work program to progress delivery of Marinus Link, including any implications for the NEM regulatory framework.

9.5. Telecommunication services

The telecommunications market continues to grow strongly, reflecting the increasing importance of these services in supporting the global economy. It is predicted that strong growth in this sector will continue with increased demand from the business sector for cloud computing, machine-to-machine communications, artificial intelligence as well as increased demand for personal connectivity.

Chapter 3 discusses the technical components of HVDC systems including the telecommunications components. The inclusion of telecommunications capability in the HVDC cable represents a small incremental cost and supports monitoring of cable condition. Investment to ensure on-island telecommunications connectivity would be required in order to be able to capitalise on the additional telecommunications capacity made available through Marinus Link.

At this stage of the feasibility assessment TasNetworks has undertaken an initial investigation as to the state of the telecommunications market, forecast demand, and service provision options. Marinus Link presents an opportunity to increase competition in the provision of telecommunication services on the Bass Strait route, resulting in improved reliability and service security. To deliver these benefits for customers, fit for purpose commercial arrangements will need to be negotiated, enabling onward connectivity.

The Final Feasibility and Business Case Assessment Report will include further detail as to potential telecommunication service provision.

9.6. Next steps

During 2019, further investigation will be undertaken on the various commercial models, including refining how revenue can be derived from Marinus Link under a hybrid or merchant model. This will involve the exploration of the potential service offerings of Marinus Link, ensuring appropriate return can be obtained, while also investigating other interconnector models (in international markets, for example), and how they may be applied in the NEM regulatory framework. As this work progresses TasNetworks will continue to engage with stakeholders to discuss options and seek feedback.

The Final Feasibility and Business Case Assessment Report forecast to be released in December 2019 will include more detail on project cost recovery options considered, including an assessment of wholesale market trading and pricing issues and arrangements. Any commercially sensitive information will not be disclosed in the public version of the Final Feasibility and Business Case Assessment Report.

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10. Stakeholder and community engagement

This chapter outlines the stakeholder and community engagement activities associated with Project Marinus that are detailed further in the Stakeholder and Community Engagement Plan (link provided in section 12.3).

A stakeholder is any party that could potentially affect or be affected by a project. Stakeholders include people or groups with a strong interest in the project.

Stakeholder and community engagement can be used for a range of reasons, including to:

- gain social licence and increase the likelihood of a project's success;
- create a more transparent and open project process;
- understand, include and give a voice to affected and interested groups;
- receive feedback from diverse groups that could contribute to a project; and
- identify issues that were previously unknown or overlooked.

Consistent with the above reasons, participatory stakeholder and community engagement is being undertaken for Project Marinus to connect, inform, consult and collaborate with project stakeholders. This engagement supports TasNetworks' understanding of stakeholder feedback about Project Marinus, and implications for the project's Feasibility and Business Case Assessment, and future project phase considerations.

Stakeholder engagement uses a range of approaches and encompasses a range of activities, tailored to the needs of the individual stakeholder groups and the specific project phases.

The success of Project Marinus, and the potential Marinus Link, will depend on gaining a level of social licence and acceptance by the community. As the project progresses, TasNetworks will assess the level of project acceptance and support by seeking regular feedback from stakeholder groups. This feedback will help to identify key issues and concerns, to acknowledge, consider and address.

Further details of Project Marinus' Stakeholder and Community Engagement are provided in the following sections:

- 10.1 Approach – outlines the method used to the design the stakeholder and community engagement activities.
- 10.2 Stakeholder groups – presents the main stakeholder groups.
- 10.3 Knowledge Sharing – describes our approach to sharing knowledge gained.
- 10.4 Next steps – outlines what is next in the continuous stakeholder and community engagement process.

10.1. Approach

Marinus Link is a large infrastructure project of regional, state and national significance that has numerous interrelating environmental, social, financial and political implications. It has the potential to impact a diverse range of stakeholder groups in many ways.

For this reason, stakeholder and community engagement is fundamental to identifying feasible interconnector solutions that deliver a positive business case and achieve community support.

Communicating with stakeholders, hearing their opinions and utilising their inputs will ultimately contribute to a better outcome and a more sustainable project.

TasNetworks will engage with stakeholders and community groups through a range of engagement methods, including:

- meetings and briefings;
- presentations;
- discussion papers;
- public forums;
- one-on-one discussions;
- website;
- direct mail; and
- social media.

These engagement activities have already commenced and will continue throughout the whole project lifecycle.

Monitoring and evaluation is essential to ensuring the effectiveness of stakeholder engagement for the Project. It also enables TasNetworks to continually improve engagement practices. After each formal engagement event, TasNetworks will seek feedback. A record of all engagement activities is maintained in the Project Marinus Stakeholder Management Tool, including contact with stakeholders and a record of enquiries, complaints and any actions that have arisen from engagement activities.

The feedback received will help to create better outcomes from the project, and ensure TasNetworks continues to utilise successful engagement techniques, and can rectify issues as they arise.

10.2. Stakeholder groups

Extensive stakeholder mapping and analysis was undertaken to identify groups who could be directly or indirectly affected by the project and groups who could have a significant influence on the project. Through this process, a list of over 300 potential stakeholders were identified. These stakeholders have been organised into eight broad stakeholder groups to ensure all engagement activities are tailored appropriately to each audience. This grouping is shown in Table 18.

Table 18 Stakeholder groups

Stakeholder Group	Stakeholders
Government and regulatory	Commonwealth Government, departments, elected officials and advisors
	State Government, departments, elected officials and advisors
	Local government elected officials and office bearers
	Energy market bodies and regulators
	Other regulatory bodies and agencies
Electricity industry and other utilities	Generation businesses
	Transmission businesses
	Distribution businesses
	Electricity retailers
	Energy associations and advocacy groups
	Gas industry businesses and groups
Customers	Large energy users
	Small customers
Community and their representatives	Local councils
	Peak bodies/advocacy groups
	Interested/affected landowners, including traditional owners
	Interested/affected local businesses
	Public of Tasmania and Victoria
	Community groups

Stakeholder Group	Stakeholders
Investors, financiers and service providers	Investors and potential investors
	Financiers
	Specialised equipment and services suppliers
Advisory	Legal
	Consultants
	Universities
	Authorities such as shipping
Internal	Shareholding ministers
	Board
	Steering Committee
	ARENA
	TasNetworks staff
Media	Radio, television, digital and print journalists
	Social media commentators
	News outlets

10.3. Knowledge Sharing

Part of the benefit of Project Marinus is sharing knowledge gained. TasNetworks has developed a knowledge sharing plan, to ensure that lessons learned and insights gained from the compiling of this Report and the Final Feasibility and Business Case Assessment Report are shared with interested stakeholders. Where appropriate, emerging insights are shared to ensure a beneficial exchange of skills, experience, and understanding. A range of intellectual property and other confidential information is also generated during the project, and this is appropriately protected to meet commercial and legal considerations.

10.4. Next steps

It is fundamental to TasNetworks that stakeholders and communities are able to express their thoughts, aspirations and concerns about the project over its lifecycle. To ensure this, our stakeholder and community engagement activities, outlined in our Stakeholder and Community Engagement Plan, will continue throughout the project.

Stakeholder engagement on this Report will include the following activities:

- town hall meetings;

- drop in centres;
- face to face meetings;
- government briefings (across State, Commonwealth and Local Governments);
- newspaper advertisements and materials;
- flyers;
- website Updates;
- social Media Updates; and
- email Updates to our Mailing List.

Further information and the Stakeholder and Community Engagement Plan is available on our website[140] or by contacting the Project Team.

Stakeholder and community engagement to support the Final Feasibility and Business Case Assessment Report will continue throughout 2019 including release of the report forecast for December 2019.

[140] https://projectmarinus.tasnetworks.com.au/assets/Stakeholder-and-Community-Engagement-Plan.pdf

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11. Seeking your feedback

This chapter notes feedback received on the first RIT-T engagement process, then sets out questions for feedback on the broader Feasibility and Business Case Assessment for a second Bass Strait interconnector. It also provides our contact information.

11.1. Feedback received on regulatory process engagement

The RIT-T process requires extensive analysis and consultation, and is subject to independent review by the AER, to ensure outcomes are efficient. In July 2018 TasNetworks released the first consultation document under the RIT-T process – the Project Specification Consultation Report – to consider a second Bass Strait interconnector. Submissions closed in late October 2018.

Submissions reinforced the requirement for rigorous analysis and consultation to ensure good customer outcomes. Feedback covered a number of broad themes relating to:

- the transparent consultation process undertaken by TasNetworks;
- integration with AEMO's ISP;
- performance of Basslink;
- potential benefits of Project Marinus;
- project costs;
- investment assessment and modelling;
- project design – particularly relating to connection point considerations; and
- project funding.

A summary of the RIT-T feedback is in Appendix 5, with full copies of submissions published on TasNetworks' website[141]. Some of the matters raised are not able to be considered under the present RIT-T framework, but are relevant to considering the feasibility and business case of a second Bass Strait interconnector.

This Report includes information that addresses a number of issues raised in the RIT-T submissions. Further information will be developed and shared as the Feasibility and Business Case Assessment, including the RIT-T process, continues.

[141] https://www.tasnetworks.com.au/customer-engagement/submissions/

11.2. Questions for Feedback

Responses to the following questions will support our understanding of stakeholder views on this Report and inform our future work:

1. Is there enough information in this Report to understand the value Marinus Link can provide? If not, what information would you like to see in future reports?
2. What aspects of the report need further explanation?
3. Are there any fundamental concerns with our analysis in this Report? And if so, what are these concerns and how could we address them?
4. Do you agree with our assessment that it is prudent to continue Project Marinus through to the Definition and Approvals phase? Why is that?
5. If Marinus Link provides greater benefits than costs as part of efficient transition of Australia's NEM, then what principles should be taken into account when considering:
    a. who should pay to progress Marinus Link?
    b. who should pay for the national energy market benefits Marinus Link provides?
    c. who should pay for the broader benefits beyond the energy sector that Marinus Link provides?
6. Is there any other feedback that you would like to provide, to help us consider the feasibility and business case for a second Bass Strait interconnector?

11.3. Contact us

Stakeholders and interested communities are invited to contact Project Marinus to request a briefing, give feedback on this Report, express concerns or make enquiries on the project. As part of our ongoing commitment to engagement, queries, issues and concerns will be addressed in a timely manner.

As detailed in Chapter 10, the Project Marinus Community Engagement Team provides multiple channels for stakeholders to learn about the project and make contact. This includes contacting the Project Marinus team directly via the means provided in Table 19 below.

Table 19 Project Marinus contact details

Contact medium	How to contact us
Write to us	Tasmanian Networks Pty Ltd PO Box 606 Moonah Tasmania 7009
Email us	projectmarinus@tasnetworks.com.au
Website	www.tasnetworks.com.au projectmarinus.tasnetworks.com.au
Call us	1800 060 399 (within Tasmania) 03 6271 6000
Social Media	Private message via TasNetworks' Facebook page

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12. Glossary and References

12.1. Glossary of terms

Terms	Description
Accuracy allowance (in cost estimate)	Accuracy allowances are a measure of an estimates/element's certainty, they are a factor that is applied to the base estimate to reflect the inherent risk in the assessed cost of a planned scope of work.
Ancillary services	Ancillary services perform the essential role of ensuring a continuously stable power system operation, especially when subjected to unforeseen contingency events. Examples include a device which can rapidly alter the network voltage to correct for voltage disturbances (caused, for example, by a lightning strike), or the ability of a generator to rapidly change its power output in response to a sudden change in customer demand. Ancillary services are defined in the Rules as 'market ancillary services' and 'non-market ancillary services'. See chapter 10 of the Rules for more detail.
Battery of the Nation	An initiative by Hydro Tasmania, supported by funding from ARENA, investigating and developing a pathway of future development opportunities for Tasmania to make a greater contribution to the NEM. (Web link in section 12.3)
Base Estimate	A cost estimate that includes the costs of all sub-component activities from the initiation of the project to finalisation, without allowance for the accuracy of any quantities or rates utilised, or the risks associated with these activities. The base estimate is equivalent to a P50 value, that is to say there is a 50% chance the actual cost will be higher or lower than the base estimate.
Capex	Capital expenditure; the expenditure required to develop and construct an asset
Contingency allowance (in cost estimate)	An amount added to the estimate to allow for changes that experience shows will likely be required. Quantification of contingency allowances for cost estimating items is achieved by applying risk management processes.
Contingency event	An event affecting the power system which AEMO expects would be likely to involve the failure or removal from operational service of one or more generating units and/or transmission elements (Rules clause 4.2.3(a)) e.g. lightning striking a transmission line, a sudden unexpected generator failure, bushfire smoke causing a short-circuit between transmission circuits.
Contingent Project	Contingent projects are significant network augmentation projects that are reasonably required to be undertaken in order to achieve the capital expenditure objectives as defined in the National Electricity Rules. However, unlike other proposed capital expenditure projects, the need for the project within the regulatory control period and the associated costs are not sufficiently certain.
Credible	Reasonably possible in the surrounding circumstances.

Terms	Description
Credible contingency event	A contingency event that is considered reasonably possible in the surrounding circumstances e.g. loss of a single generator, load or circuit in the network; loss of multiple circuits in a transmission corridor in the presence of a severe bushfire. The technical definition of a credible contingency event can be found in clause 4.2.3(b) of the Rules.
Non-credible contingency event	Non-credible contingency event - a contingency event that is not considered reasonably possible in the surrounding circumstances e.g. coincident loss of multiple generators; loss of multiple transmission circuits without the presence of adverse weather conditions. The technical definition of a credible contingency event can be found in clause 4.2.3(e) of the Rules.
Dispatchable on-demand	A generator, such as a hydro, gas or coal fuelled generator, in which the electrical output can be increased or decreased as required in order to meet varying customer demand. This contrasts with non-dispatchable generators, such as solar and wind, the output of which will fluctuate depending on the input power source.
Economic worth	The economic value of the benefits of a project minus its costs, expressed in net present value terms.
Energy security	Refers to the certainty of being able to supply customers' energy needs in the medium and long term.
Escalation factor (in cost estimate)	The escalation factor is added to the base estimate, interest during construction, accuracy allowance and contingency allowance to convey the total estimate from present day costs into dollars of the period that the work is expected to be performed.
Final Investment Decision	Relates to the stage in a project where everything is in place to execute the project (contracts can be signed). Getting to this stage involves arranging all financing, permits, approvals and any other requirements that are needed prior to construction starting. It is the point where contracts for all major equipment can be placed, allowing procurement and construction to proceed and engineering to be completed.
Firm/ Firming	Firming, in relation to variable generation sources such as solar or wind, is the action of adding additional power from a separate dispatchable on-demand source that can compensate for the potential lack of output from a variable generator when the power is needed.
Hybrid Model	(In reference to a service model for an interconnector) An arrangement that allows for recovery of the cost to construct and operate the interconnector via a combination of Merchant and Regulated models.
Integrated System Plan	A plan prepared by AEMO that forecasts the overall transmission system requirements for the NEM over the next 20 years. (Web link in section 12.3)
Interest During Construction (in cost estimate)	Interest costs on funding a project under construction, prior to capitalisation.
Job years	Represents one full-time job for a 12 month period of time.
Land assembly requirements	All of the land tenure and consents required to enter and use land for the construction and operation of Marinus Link.

Terms	Description
Level 1 cost estimate	A high level estimate for project concept stage, to perform feasibility and options analysis, considering scope and time only.
Level 2 cost estimate	A detailed estimate for project development stage, to evaluate preferred option, considering scope, time and contingent risk.
Level 3A cost estimate	A further refined detailed estimate for project implementation stage, to support business case approval, considering all project management elements;
Level 3B cost estimate	A detailed estimate with market feedback for project implementation stage following receipt of offers and pre-contract award, incorporating actual market prices to support effective cost control and reporting.
Likely	Greater than 50% probability of occurrence.
Load shedding	Reducing or disconnecting load from the power system. (Rules chapter 10).
Marinus Link	A proposed second transmission interconnector linking Tasmania and Victoria
Merchant model (also referred to as 'unregulated')	(In reference to a service model for an interconnector) An arrangement that allows for recovery of the cost to construct and operate the interconnector via trading between regional electricity markets and/or via service agreements with counterparties.
The National Electricity Objective	As stated in National Electricity Law is: "to promote efficient investment in, and efficient operation and use of, electricity services for the long term interests of consumers of electricity with respect to: • price, quality, safety and reliability and security of supply of electricity • the reliability, safety and security of the national electricity system."
NEM Regulatory process	(In reference to the cost recovery for transmission services): The process of seeking approval to provide a regulated service via the regulatory investment test for transmission; obtaining a revenue allowance which includes an amount to recover the costs associated with providing that service, and recovering that revenue amount from customers via approved transmission pricing. This process requires approval by the Australian Energy Regulator at each step. See also 'Regulated Model'.
Net present value	The difference between the present value of benefits and the present value of costs over a period of time.
On-demand	Available when requested or required.
Opex	Operational expenditure; the ongoing expenditure required to operate and maintain assets and the supporting activities to provide services.
P50	P50 costs are estimates of project costs based on 50 percent probability that the cost estimate will not be exceeded.
Plausible	Seeming reasonable or probable,
Project Assessment Draft Report	The second step in the RIT-T process.

Terms	Description
Project Marinus	The project established by TasNetworks, with funding support from ARENA and the Tasmanian Government, to complete a detailed Feasibility and Business Case Assessment of a second Bass Strait interconnector, known as Marinus Link
Regulated Model	(In reference to a service model for an interconnector) An arrangement that allows for recovery of the cost to construct and operate an interconnector by including the costs of the interconnector in regulated transmission charges paid by electricity customers. See also 'NEM Regulatory process'.
Reliability	See "Supply reliability".
The Reliability Standard	The reliability standard that applies to the NEM is the primary mechanism to signal the market to deliver enough capacity to meet customers' demand for electricity. The standard is set out in clause 3.9.3C of the Rules. Reliability under the standard is measured in terms of maximum expected unserved energy. Currently the reliability standard is set at 0.002 per cent unserved energy per region or regions per financial year. e.g out of 100,000MWh of demand, no more than 2MWh of forecast unserved energy would be allowed.
Revenue allowance	The annual revenue that a TNSP is allowed, by the AER, to recover for its regulated services. The Rules define the revenue allowance as the 'aggregate annual revenue requirement', the detailed definition is set out in clause 6A.22.1 of the Rules.
Rules	The National Electricity Rules.
Run of river storage schemes	Small storages with limited variation in level, usually in a sequence, and responding largely to inflows (river flows and rainfall); e.g. the Derwent, Pieman and Forth systems in Tasmania
Power system security	Operation of the power system within its technical limits (for frequency, voltage, etc.) such that it will maintain stable operation including after a contingency.
Service model	(In reference to Marinus Link) The financial model for recovery of the costs of providing Marinus Link services.
Shovel ready	A project for which approvals have been obtained and major design work is complete, allowing construction to start relatively quickly when required and funded.
Supply reliability	Maintaining sufficient capacity (generation, network, and demand response) to meet customer power demands in the short-term.
System strength	A measure of the stability of a power system under all reasonably possible operating conditions.
The Initial Feasibility Study	The work and analysis undertaken to prepare this Initial Feasibility Report
The Final Feasibility and Business Case Assessment Report	The report which will describe the outcomes from the next stage of detailed assessment, forecast to be released in December 2019
The Tamblyn study	A study commissioned by the Tasmanian and Commonwealth governments into a second Bass Strait interconnector. (Web link in section 12.3)
Tasmanian Energy Security Taskforce Report	A report prepared by the taskforce established by the Tasmanian government to advise the government on how it can better prepare for, and

Terms	Description
	mitigate against, the risk of future energy security events. This report is often to as 'the Willis Review' (Web link in section 12.3)
Unserved energy	The volume of energy that customers desired but could not supplied (e.g. due to a blackout). The technical definition of unserved energy is set out in chapter 10 of the Rules.
Upgrade	(in relation to a transmission network) works to enlarge the transmission network or increase its capacity to transmit electricity, also known as augmentation (augmentation is defined in the National Electricity Law).
Variable renewable generation	The forms of electricity generation that depend on a primary energy source that varies with time and cannot be stored. Solar and wind generation are the most common forms of variable renewable generation.

12.2. Glossary of acronyms

Terms	Description
2018 ESOO	AEMO’s 2018 Electricity Statement of Opportunities
AC	alternating current
ACCC	Australian Competition and Consumer Commission
AEMO	Australian Energy Market Operator
AEMC	Australian Energy Market Commission
AER	Australian Energy Regulator
ARENA	Australian Renewable Energy Agency
capex	capital expenditure
CREG	Commission for Electricity and Gas Regulation (Belgium)
DC	direct current
DER	Distributed energy resources
EY	Ernst & Young
FCAS	frequency control ancillary services
GW	gigawatts
GWh	gigawatt hour
HV	high voltage
HVAC	high voltage alternating current
HVDC	high voltage direct current
ISP	AEMO’s 2018 Integrated System Plan
kV	kilovolt
LCC	line commutated converter
M	million
MIND	mass impregnated non-draining
MLEC	modified load export charge
MNSP	market transmission network service provider
MW	megawatts
MWh	megawatt hour
NEL	National Electricity Law
NEM	National Electricity Market
NER	National Electricity Rules

Terms	Description
NPV	net present value (also see Glossary entry)
Ofgem	Office of Gas and Electricity Markets (UK)
opex	operating expenditure
QNI	Queensland to New South Wales Interconnector
QRET	Queensland Renewable Energy Target
RIT-T	regulatory investment test for transmission
RAB	regulatory asset base
SRAS	system restart ancillary services
TNSP	transmission network service provider
TVPS	Tamar Valley Power Station
VAPR	Victorian annual planning report
VSC	voltage source converter
VRET	Victorian Renewable Energy Target
XLPE	cross-linked polyethylene

PROJECT MARINUS

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12.3. Referenced documents

Author	Reference	Source
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Australian Energy Market Operator	Integrated System Plan, July 2018	https://www.aemo.com.au/-/media/Files/Electricity/NEM/Planning_and_Forecasting/ISP/2018/Integrated-System-Plan-2018_final.pdf
Australian Energy Market Operator	Operational and market challenges to reliability and security in the NEM, March 2018	https://www.aemo.com.au/-/media/Files/Media_Centre/2018/AEMO-observations.pdf
Australian Energy Market Operator	Power System Requirements Reference Paper, March 2018	https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Power-system-requirements.pdf
Australian Energy Market Operator	Electricity Forecasting Insights report, 2017	http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/Electricity-Forecasting-Insights/2017-Electricity-Forecasting-Insights
Australian Energy Market Operator	Interactive Map	http://www.aemo.com.au/aemo/apps/visualisations/map.html
Australian Energy Market Operator	Victorian Annual Planning Report, 2018	https://www.aemo.com.au/Media-Centre/2018-Victorian-Annual-Planning-Report---VAPR
Australian Energy Market Operator	National Transmission Network Development Plan, 2016	https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/National-Transmission-Network-Development-Plan
Australian Energy Market Operator	Interconnector Capabilities, 2017	https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Congestion-Information/2017/Interconnector-Capabilities.pdf
Australian Energy Market Commission	Options paper: Coordination of Generation and Transmission Investment	https://www.aemc.gov.au/markets-reviews-advice/reporting-on-drivers-of-change-that-impact-transmi
Australian Energy Market Commission	National Electricity Rules	https://www.aemc.gov.au/regulation/energy-rules/national-electricity-rules
Australian Energy Regulator	Regulatory investment test for transmission application guidelines, 18 September 2017	https://www.aer.gov.au/networks-pipelines/guidelines-schemes-models-reviews/rit-t-and-rit-d-application-guidelines-minor-amendments-2017

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AusNet Services	Project Marinus PSCR Feedback, 26 October 2018	https://projectmarinus.tasnetworks.com.au/assets/RIT-T-submissions/RIT-T%20PSCR%20submission%20-%20AusNet%2026%20October%202018.pdf
Council of Australian Governments	Energy Security Board Converting the ISP into action, September 2018	http://coagenergycouncil.gov.au/publications/energy-security-board-converting-isp-action
CSIRO	Low Emission Technology Roadmap	https://www.csiro.au/en/Do-business/Futures/Reports/Low-Emissions-Technology-Roadmap
Dr Alan Finkel et al	Finkel Review	*Independent review into the future security of the National Electricity Market: Blueprint for the future*, June 2017: https://www.energy.gov.au/publications/independent-review-future-security-national-electricity-market-blueprint-future
Dr John Tamblyn	Tamblyn review	*Feasibility of a second Tasmanian interconnector - Final Study*, April 2017: https://www.energy.gov.au/sites/g/files/net3411/f/feasibility-second-tas-interconnector-final-report-2017.pdf
Electricity Supply Industry Expert Panel	An Independent Review of the Tasmanian Electricity Supply Industry, Final Report, Volume II	http://www.electricity.dpac.tas.gov.au/final_report
Hydro Tasmania	2016 Annual Report	https://www.hydro.com.au/about-us/our-governance/annual-report
Hydro Tasmania	Battery of the Nation: Analysis of the future National Electricity Market	https://www.hydro.com.au/docs/default-source/clean-energy/battery-of-the-nation/future-state-nem-analysis-full-report.pdf?sfvrsn=25ce928_0
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TasNetworks	Project Marinus Stakeholder and Community Engagement Plan, September 2018	https://projectmarinus.tasnetworks.com.au/assets/Stakeholder-and-Community-Engagement-Plan.pdf
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TasNetworks	2019-24 Revenue Proposal	https://www.tasnetworks.com.au/our-network/network-revenue-pricing/revenue-proposals/
UPC Renewables	Project Marinus PSCR Feedback, 26 October 2018	https://projectmarinus.tasnetworks.com.au/assets/RIT-T-submissions/RIT-T%20PSCR%20submission%20-%20UPC%20Renewables%2026%20October%202018.pdf

13. Appendices

The appendices are located in a separate document.

Appendix 1 - Economic Modelling Report

Appendix 2 - Economic Contribution to Tasmania

Appendix 3 - Tasmanian Electricity Market Simulation Model

Appendix 4 - Project Specification Consultation Report related feedback from stakeholders

Appendix 5 - Letter of review Dr John Tamblyn 23 November 2018