AEMO
AUSTRALIAN ENERGY MARKET OPERATOR
Victorian Planning

ISP Preparatory Activities South West Victoria REZ Expansion

July 2023

Important notice

Purpose

AEMO has prepared this Preparatory Activities Report in accordance with clause 5.22.6(d)(2) of the National Electricity Rules and in response to the 2022 ISP to, among other things, provide detailed information regarding possible options to increase network capacity within south-west Victoria (comprising the V4 onshore and V8 offshore renewable energy zones (REZs)), for consideration in the next ISP in forming its NEM-wide optimal development pathway.

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1 Introduction

The *Integrated System Plan* (ISP) supports Australia's highly complex and rapid energy transformation towards net zero emissions, enabling low-cost renewable energy and essential transmission to provide consumers with reliable, safe, secure, and affordable power. It serves the regulatory purpose of identifying actionable and future ISP projects.

The 2022 ISP[1] declared South West Victoria (SWV) Renewable Energy Zone (REZ) Expansion as a future ISP project, and triggered Preparatory Activities to progress the design of the project.

This future ISP project would unlock transfer capacity to harness more renewable generation along the 500kV backbone in two south-west Victorian REZs, namely V4 (SW-VIC onshore) and V8 (SW-VIC offshore) REZs, referred to in this report as the south-west Victoria group (SWV1), as well as the Victoria to south-east South Australia (VIC-SESA) Heywood interconnector.

Under its declared network functions – including for Victorian transmission planning – set out in the National Electricity Law (NEL), AEMO Victorian Planning (AVP) is responsible for planning, contracting and directing augmentation on the Victorian electricity transmission Declared Shared Network.

In this capacity, AVP has undertaken preparatory activities for SWV1 REZ Expansion, including desktop (or high level) design, cost, easement, engineering and stakeholder assessments for multiple conceptual transmission corridors. The analysis undertaken through these preparatory activities will be used as input to the modelling for the 2024 ISP.

The Victorian Government, through VicGrid, also plays a role in transmission development in Victoria and will be introducing new legislation in early 2024 to establish the Victorian Transmission Investment Framework (VTIF). Through this framework, the Victorian Government is introducing changes to the way electricity transmission infrastructure is planned and delivered in Victoria, with greater focus on reducing impacts and providing benefits for affected Traditional Owners, local communities and landowners.

Whilst the new framework is being established, VicGrid is leading the development of transmission infrastructure to provide coordinated connection points for offshore wind developers in Gippsland and Portland to enable the first target of at least 2GW of offshore wind by 2032, as a starting point. New transmission lines will also be developed where needed to link the common connection points with the existing energy grid.

As stated in VicGrid's *Roadmap Summary Portland FactSheet*[2], this avoids having a 'spaghetti effect' of multiple transmission lines criss-crossing over the landscape, which would result in higher overall costs for energy consumers.

The analysis in this ISP Preparatory Activities Report, and the outcomes of the 2024 ISP will help inform VicGrid's understanding of the need for, and timing of, development of any transmission infrastructure in SWV1 to enable offshore wind development in Portland. However, it must be stressed that the transmission corridors investigated in this ISP Preparatory Activities Report are conceptual only.

[1] At https://aemo.com.au/energy-systems/major-publications/integrated-system-plan-isp/2022-integrated-system-plan-isp.

[2] At https://engage.vic.gov.au/download/document/31641.

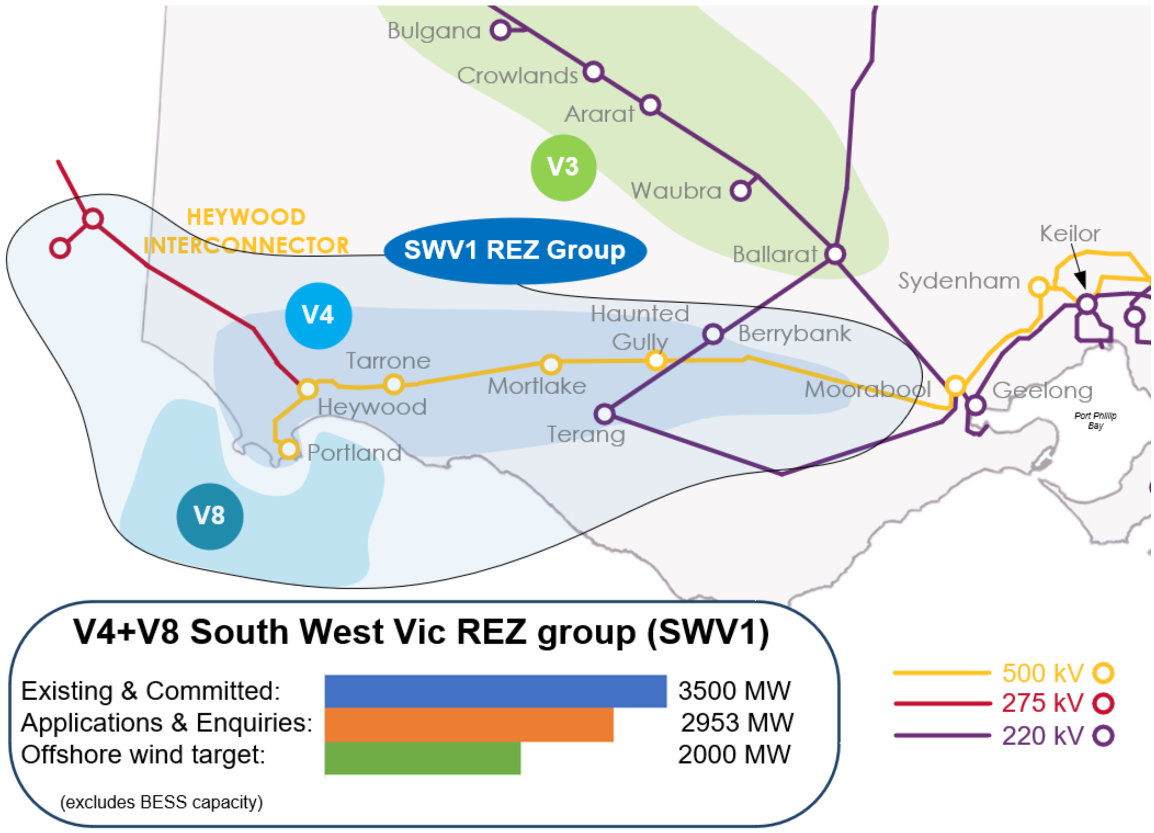
During 2023, VicGrid will progress from early planning into detailed investigations and ongoing local engagement to identify potential transmission corridors and preferred options for connection points with offshore wind generators.

1.1 Existing capacity and connections in south-west Victoria

The current total transfer capacity for SWV1 is 1,700 MW (Draft 2023 TEOR), with all generation in the REZ located onshore. The transfer capacity is currently limited due to voltage stability, which is the ability for the system to maintain or recover voltage magnitudes to acceptable levels following a contingency event[3]. Following commissioning of the REZ Development Plan stage 1 (RDP1) Mortlake turn-in project and Heywood – Moorabool 500 kV line rating upgrades, voltage stability is expected to be less limiting, and thermal limits are likely to set the total transfer capacity for the south-west Victoria REZ at approximately 3,900 MW (dependent on system conditions such as ambient temperatures, wind speeds, and pre-contingent flows).

As shown in Figure 1, there is currently 3,500 MW of existing and committed generation in south-west Victoria4 and there is significant interest in further connections in the area, with up to 2,953 MW of connection applications and enquiries. The Victorian Government also has an offshore wind target of at least 2 GW by 2032 in the Gippsland and Portland areas.

Figure 1 Summary of existing capacity and connections pipeline in Victoria



[3] See AEMO Power System Stability Guidelines, at https://aemo.com.au/-/media/files/electricity/nem/security_and_reliability/congestion-information/power-system-stability-guidelines.pdf?la=en.

[4] https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/participate-in-the-market/network-connections/nem-generation-maps, as at 26 June 2023.

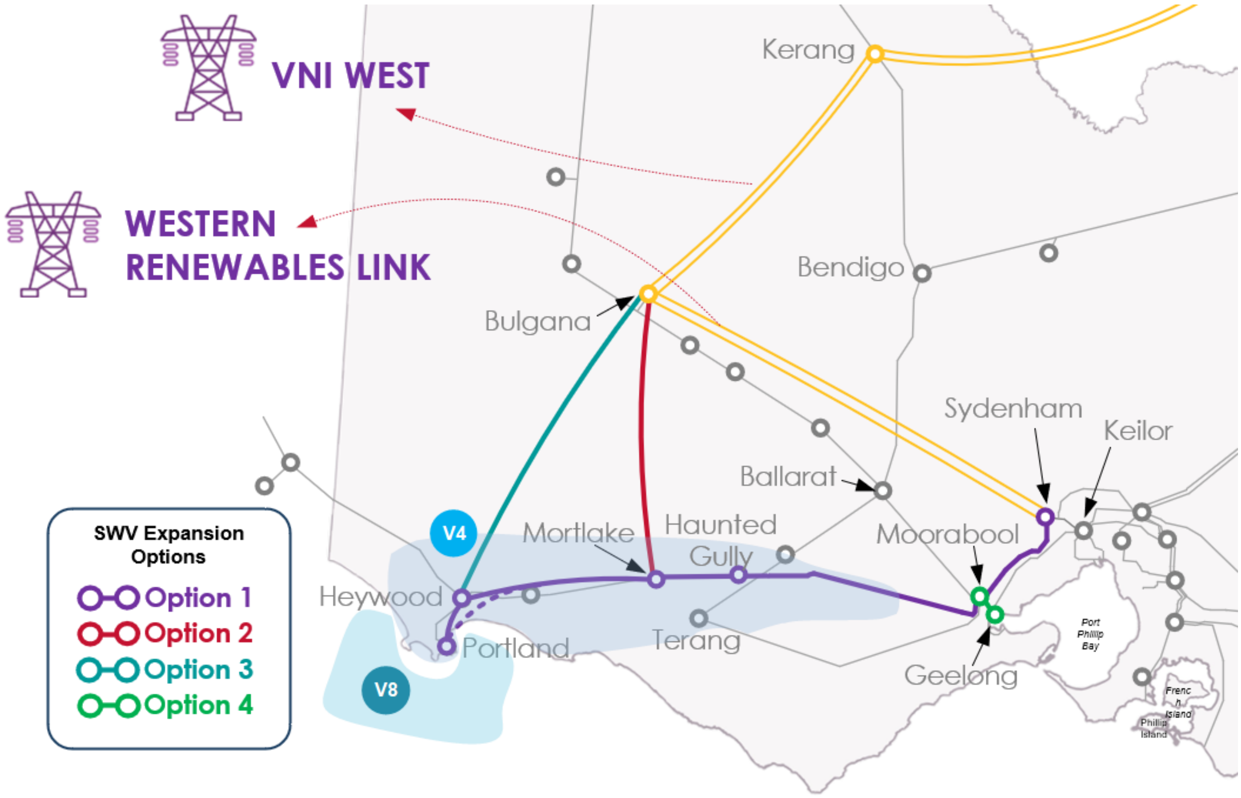
This report presents options for consideration in the 2024 ISP for increasing the current network transfer limits to unlock some, or all, of this future generation. As stated above, this is exploratory only at this stage. No decision has been made to build more transmission in south-west Victoria.

1.2 Preparatory activities for south-west Victoria

The preparatory activities process improves the conceptual design, lead time and cost estimate of the project to feed into the 2024 ISP so that sound planning decisions can be made at this early stage, based on the best information available.

The conceptual transmission corridors (credible options) considered through these preparatory activities are shown in Figure 2 below. For the purposes of these preparatory activities, the anticipated Victoria – New South Wales Interconnector West (VNI West) and Western Renewables Link (WRL) Projects (shown in yellow in the figure) are assumed to be committed ahead of any SWZ expansion.

Figure 2 Conceptual transmission corridors assessed in this report



Sub-options have also been identified focusing on different possible network upgrades that meet slightly different needs: some harnessing more on-shore renewable generation, others supporting off-shore wind development, and some addressing constraints in the network that may otherwise emerge as consequence of the SWV1 expansion. These sub-options are summarised in Table 1.

This report summarises the preparatory activities undertaken for each option/sub-option and outcomes to inform the 2024 ISP.

Table 1 Summary of the credible options assessed

Option	Description	Area unlocked	Indicative impact on REZ transmission limit (+MW)	Capital cost $m 2022-23
Option 1A	New Mortlake-Moorabool 500 kV single-circuit	Onshore supply (V4)	950	$669 - $781
Option 1A with upratings	Option 1A plus Moorabool-Sydenham line upratings	Onshore supply (V4)	1,500	$678 - $790
Option 1B	Option 1A with upratings plus new Moorabool-Sydenham 500 kV single-circuit	Onshore supply (V4)	1,750	$962 - $1,145
Option 2A	New Mortlake-Bulgana 500 kV single-circuit	Onshore supply (V4)	1,950	$578
Option 2B	New Mortlake-Bulgana 500 kV double-circuit	Onshore supply (V4)	2,900	$751
Option 2C	Option 2A plus 1B	Onshore supply (V4)	3,750	$1,490 - $1,684
Option 2D	Option 2B plus 1B	Onshore supply (V4)	4,700	$1,648 - $1,836
Option 1C	Option 1B plus new Heywood-Mortlake 500 kV single-circuit	SESA-VIC	1,750	$1,290 - $1,491
Option 1D	Option 1A plus Alcoa Portland-Heywood line upratings	Offshore supply (V8)	950	$676 - $787
Option 1E	Option 1C plus new Alcoa Portland-Heywood 500 kV single-circuit[A]	Offshore supply (V8)	1,750	$1,419 - $1,611
Option 3A	New Heywood-Bulgana 500 kV single-circuit plus new Alcoa Portland-Heywood 500 kV single circuit[A]	Offshore supply (V8)	1,800	$1,006
Option 3B	New Heywood-Bulgana 500 kV double-circuit plus new Alcoa Portland-Heywood 500 kV single-circuit[A]	Offshore supply (V8)	2,800	$1,239
Option 4A	New Moorabool-Geelong 220 kV single-circuit	Metro access	NA	$39 - $82
Option 4B	Moorabool-Geelong 220 kV line upratings	Metro access	NA	$58 - $101

A. With existing line upratings.

2 High level network augmentation Overview

Four high level options have been considered for SWV1 expansion:

- A new 500 kV line that follows existing easements of the existing 500 kV double-circuit lines from Heywood through to Moorabool to Sydenham (brownfield environment)
- New 500 kV lines connecting the proposed VNI West at Bulgana TS with the existing South-West 500 kV lines at Mortlake (greenfield environment towards Bulgana)
- New 500 kV lines connecting the proposed VNI West at Bulgana TS with the existing South-West 500 kV lines at Heywood (greenfield environment towards Bulgana)
- Augmentation of the existing 220 kV lines from Moorabool to Geelong to help alleviate congestion that may otherwise arise from the above options, as a result of the increased generation unlocked by these options at times when supplying Victorian metropolitan load (brownfield environment)

For each, a number of sub-options have been identified, ranging from smaller benefit and smaller cost to larger benefit and larger cost for flexibility in the ISP model, with some options large enough to unlock generation levels consistent with the current applications pipeline.

At a high level, these sub-options consider:

- **Adding dynamic line rating capability to existing lines** – which allows monitoring of certain conditions such as ambient temperature and the real-time loading of the lines, such that more accurate loading capability can be calculated and short-term ratings (which are higher than continuous ratings) can be utilised
- **Upgrading equipment to run to conductor ratings** – in some instances, the allowable loading on a conductor may be limited by ratings of plant at the terminal station, rather than by the ratings of the conductor itself. In these cases, the terminal station plant may be upgraded to plant with higher ratings than the conductor ratings, thus allowing the conductors to be loaded to conductor ratings. This usually happens when upgrades of the lines occur (such as adding dynamic line ratings) and thus assumptions of use have changed from when they were first designed and built.
- **Augmentation of terminal stations –** when building new transmission lines, existing terminal stations that these lines enter and exit often need to be augmented to accommodate these lines. This augmentation typically includes the building of new bays and other equipment such as reactors and protection and control panels.
- **Constructing new transmission lines, either single circuit or double circuit** – single-circuit lines, which is one set of three conductors, may be strung on either single-circuit towers (which makes full use of the towers), or double-circuit towers (where only one half of the tower is used, and allows for another circuit to be strung later on). Double-circuit lines are two sets of three conductors, and can only be strung on double-circuit towers. Easement widths will vary slightly between single or double-circuit towers, reflecting different sizes between transmission tower types.

Table 2 provides a more detailed description of each of these options and sub-options considered in these preparatory activities.

Table 2 SWV1 augmentation options

Option	Description	Capacity unlocked
1A	A new 500 kV single-circuit from Mortlake terminal station to Moorabool terminal station, along with augmentation of these terminal stations to accommodate the new line.	Onshore only
1A with line up-ratings	Option 1A Upgrades at Moorabool and Sydenham terminal stations to allow existing 500 kV circuits from Moorabool to Sydenham to run to conductor ratings, and enablement of dynamic ratings for these circuits.	Onshore only
1B	Option 1A with line up-ratings A new 500 kV single-circuit from Moorabool terminal station to Sydenham terminal station, along with augmentation of these terminal stations to accommodate the new line	Onshore only
1C	Option 1B A new 500 kV single-circuit from Heywood terminal station to Mortlake terminal station, along with augmentation of these terminal stations to accommodate the new line	Onshore and SESA-VIC transfer
1D	Option 1A Upgrades at Alcoa Portland[A] and Heywood terminal stations to allow existing 500 kV circuits from Alcoa Portland to Heywood to run to conductor ratings, and enablement of dynamic ratings for these circuits.	Onshore and offshore
1E	Option 1C Upgrades at Alcoa Portland[A] and Heywood terminal stations to allow existing 500 kV circuits from Alcoa Portland to Heywood to run to conductor ratings, and enablement of dynamic ratings for these circuits. A new 500 kV single-circuit from Alcoa Portland[A] terminal station to Heywood terminal station, along with augmentation of these terminal stations to accommodate the new line.	Onshore, offshore, and SESA-VIC transfer
2A	A new 500 kV single-circuit from Mortlake terminal station to Bulgana terminal station, along with augmentation of these terminal stations to accommodate the new line.	Onshore only
2B	A new 500 kV double-circuit from Mortlake terminal station to Bulgana terminal station, along with augmentation of these terminal stations to accommodate the new lines.	Onshore only
2C	Option 2A Option 1B	Onshore only
2D	Option 2B Option 1B	Onshore only
3A	A new 500 kV single-circuit from Heywood terminal station to Bulgana terminal station, along with augmentation of these terminal stations to accommodate the new line. Upgrades at Alcoa Portland and Heywood terminal stations to allow existing 500 kV circuits from Alcoa Portland to Heywood to run to conductor ratings, and enablement of dynamic ratings for these circuits. A new 500 kV single-circuit from Alcoa Portland[A] terminal station to Heywood terminal station, along with augmentation of these terminal stations to accommodate the new line.	Offshore and SESA-VIC transfer
3B	A new 500 kV double-circuit from Heywood terminal station to Bulgana terminal station, along with augmentation of these terminal stations to accommodate the new lines. Upgrades at Alcoa Portland**Error! Bookmark not defined.** and Heywood terminal stations to allow existing 500 kV circuits from Alcoa Portland to Heywood to run to conductor ratings, and enablement of dynamic ratings for these circuits. A new 500 kV single-circuit from Alcoa Portland**Error! Bookmark not defined.** terminal station to Heywood terminal station, along with augmentation of these terminal stations to accommodate the new line.	Offshore and SESA-VIC transfer
4A	A new 220 kV single-circuit from Moorabool terminal station to Geelong terminal station, along with augmentation of these terminal stations to accommodate the new line.	Metro constraint
4B	Upgrades at Moorabool and Geelong terminal stations to allow existing 220 kV circuits from Moorabool to Geelong to run to conductor ratings	Metro constraint

A. This assumes offshore wind being connected to a new terminal station near the existing Alcoa Portland site which will make use of the existing Heywood Terminal Station (HYTS)-Alcoa Portland (APD) 500 kV lines.

The 2024 ISP will determine if any of these options/sub-options optimise benefits for consumers and consequently form part of the next optimal development path. In determining this, the ISP model will assess trade-offs between costs and benefits of the various options provided. These options are not mutually exclusive. The ISP is free to select combinations of options in a staged approach if beneficial to do so (while utilising the cost breakdowns to appropriately adjust costs).

For example, in order to facilitate larger levels of wind capacity than these options present (such as offshore wind capacity levels beyond the amounts indicated in Table 7), the following options may be combined[5]:

- Option 3A and 1C.
- Option 3B and 1C.
- Option 2A and 1E.
- Option 2B and 1E.

[5] To sufficiently cost these options, it is important to adjust the individual option costs where components may overlap – as can be identified from the options' detailed cost breakdowns.

3 Preliminary engineering design

3.1 Single line diagrams

An overall single line diagram has been produced for each option to inform estimating (see Attachment 1).

3.2 Detailed descriptions

Option 1A and 1A with line uprating

Option 1A consists of a new 500 kV single-circuit transmission line between Moorabool Terminal Station (MLTS) and Mortlake Power Station (MOPS). In order to facilitate this expansion, a new 500 kV line is to be constructed from MLTS to MOPS with two intermediate tie-ins at Cressy Terminal Station (CRTS) and Haunted Gully Terminal Station (HGTS) respectively for the new MLTS 1/HGTS 1, and the reconfigured MLTS 2&3 (previous MLTS 1&2) lines. In addition to the installation of a single circuit 500 kV transmission line between MLTS-MOPS, modifications are required at the following stations:

- Moorabool (MLTS).
- Cressy (CRTS).
- Haunted Gully (HGTS).
- Mortlake (MOPS).

Option 1A with line uprating includes the components of Option 1A with the addition of uprating the existing MLTS1-SYTS1 and MLTS2-SYTS2 500 kV lines, including dynamic rating enablement, secondary and protection system modification, and line traps/droppers uprating works.

Option 1B

Option 1B includes the components of Option 1A (including 1A with line uprating) with the addition of a new 500 kV transmission line between SYTS and MOPS. Under this option a new 500 kV line (SYTS 3) is to be constructed from SYTS to MLTS (due to easement constraints it is expected that a portion of this line would need to be underground cable) and from MLTS to MOPS (MLTS 1/CRTS 1/HGTS 1/MOPS) with two intermediate cut-ins at CRTS and HGTS respectively, and a reconfiguration of the existing lines to suit the new switchyard configurations at each station.

In addition to the installation of a single circuit 500 kV transmission line between SYTS-MOPS, modifications are required at the following facilities:

- Sydenham (SYTS).
- Moorabool (MLTS).
- Cressy (CRTS).
- Haunted Gully (HGTS).
- Mortlake (MOPS).

Option 1C

Option 1C includes the components of Option 1B with the addition of a new 500 kV transmission line between Mortlake Power Station (MOPS) and Heywood Terminal Station (HYTS).

To facilitate this expansion, a new 500 kV line will would be constructed from SYTS to MLTS and from MLTS to MOPS with two intermediate tie-ins at CRTS and HGTS respectively for the new MLTS 1/HGTS 1. In addition, a new 500kV transmission line between MOPS to HYTS would need to be constructed with an intermediate tie-in at TRTS and a reconfiguration of the existing lines to suit the new switchyard configurations at each station.

In addition to the installation of a single circuit 500 kV transmission line between SYTS-HYTS, modifications are required at the following facilities:

- Sydenham (SYTS).
- Moorabool (MLTS).
- Cressy (CRTS).
- Haunted Gully (HGTS).
- Mortlake (MOPS).
- Tarrone (TRTS).
- Heywood (HYTS).

Option 1D

Option 1D includes the components of Option 1A with the addition of uprating the existing HYTS1-Alcoa Portland (APD) 1 and HYTS2-APD2 500 kV lines, including dynamic rating enablement. The existing instrumentation on the APD-HYTS1 and APD-HYTS2 lines at HYTS are currently the limiting plant requiring up-rating.

Option 1E

Option 1E includes the components of Option 1C with the addition of a new 500kV transmission line between HYTS and a new Terminal Substation to be constructed in Portland.

To facilitate this expansion, a new 500 kV lines would need to be constructed from SYTS to MLTS and from MLTS to MOPS with two intermediate tie-ins at CRTS and HGTS respectively for the new MLTS 1/HGTS 1, and the reconfigured MLTS 2&3 (previous MLTS 1&2) lines. A new 500 kV line would also need to be constructed from MOPS to HYTS with an intermediate tie-in at TRTS for the new MOPS 1/TRTS 1, and the reconfigured HYTS 1/TRTS1 (previous HYTS 1/MOPS 1) line. Finally, a new 500 kV line is required to be constructed from HYTS to a new terminal station to be constructed in Portland, near to the existing APD 500/220 kV Substation. Construction the new terminal station at Portland is excluded from the scope of the SW VIC REZ.

The installation of these new single circuit 500 kV transmission lines between SYTS and Portland, will require modifications at the following existing facilities:

- Sydenham (SYTS).
- Moorabool (MLTS).
- Cressy (CRTS).

- Haunted Gully (HGTS).
- Mortlake (MOPS).
- Tarrone (TRTS).
- Heywood (HYTS).

Option 2A

Option 2A consists of network expansion to add a new 500kV single-circuit transmission line between BGTS and MOPS. Options 2A and 2B are differentiated by the number of circuits on the line; 2A refers to the single circuit option.

In addition to the construction of a single circuit 500 kV transmission line between BGTS-MOPS, modifications are required at the following facilities:

- Bulgana (BGTS).
- Mortlake (MOPS).

Option 2B

Option 2B consists of network expansion to add a new 500kV double-circuit transmission line between BGTS and MOPS.

In addition to the construction of a double circuit 500 kV transmission line between BGTS-MOPS, modifications are required at the following facilities:

- Bulgana (BGTS).
- Mortlake (MOPS).

Option 2C

Option 2C includes the components of Option 2A and Option 1B.

To facilitate this expansion, the following transmission line additions and modifications are required:

- Single circuit 500 kV BGTS-MOPS (new).
- Single circuit 500 kV MOPS-HGTS (new).
- Single circuit 500 kV HGTS-CRTS (new).
- Single circuit 500 kV CRTS-MLTS (new).
- Single circuit 500 kV MLTS-SYTS (new).

In addition to the installation of the noted transmission lines, modifications are required at the following facilities:

- Bulgana (BGTS).
- Mortlake (MOPS).
- Cressy (CGTS).
- Haunted Gully (HGTS).

- Moorabool (MLTS).
- Sydenham (SYTS).

Option 2D

Option 2D includes the components of Option 2B and Option 1B.

To facilitate this expansion, the following transmission line additions and modifications are required:

- Double circuit 500 kV BGTS-MOPS (new).
- Single circuit 500 kV MOPS-HGTS (new).
- Single circuit 500 kV HGTS-CRTS (new).
- Single circuit 500 kV CRTS-MLTS (new).
- Single circuit 500 kV MLTS-SYTS (new).

In addition to the installation of the noted transmission lines, modifications are required at the following facilities:

- Bulgana (BGTS).
- Mortlake (MOPS).
- Cressy (CGTS).
- Haunted Gully (HGTS).
- Moorabool (MLTS).
- Sydenham (SYTS).

Option 3A

Option 3A consists of network expansion to add a new 500kV single-circuit transmission line between BGTS and HYTS, and a new 500kV single-circuit transmission line between HYTS and Portland, in addition to uprating limiting station plant at HYTS for the existing 500kV lines between HYTS and APD.

To facilitate this expansion, the following transmission line additions and modifications are required:

- Single circuit 500 kV BGTS-HYTS (new).
- Single circuit 500 kV HYTS-Portland (new).
- Uprate existing limiting plant (instrumentation) at HYTS.

In addition to the installation of the noted transmission lines, modifications are required at the following facilities:

- Bulgana (BGTS).
- Heywood (HYTS).
- Portland terminal station (out of scope, by others).

Option 3B

Option 3B consists of network expansion to add a new 500kV double-circuit transmission line between BGTS and HYTS, and a new 500kV single-circuit transmission line between HYTS and Portland, in addition to uprating limiting station plant at HYTS for the existing 500kV lines between HYTS and APD.

To facilitate this expansion, the following transmission line additions and modifications are required:

- Double circuit 500 kV BGTS-HYTS (new).
- Single circuit 500 kV HYTS-Portland (new).
- Uprate existing limiting plant (instrumentation) at HYTS.

In addition to the installation of the noted transmission lines, modifications are required at the following facilities:

- Bulgana (BGTS).
- Heywood (HYTS).
- Portland terminal station (out of scope, by others).

Option 4A

Option 4A consists of the construction of a new 220kV single-circuit transmission line between MLTS and GTS.

The installation of a single circuit 220 kV transmission line between MLTS-GTS, requires modifications at the following facilities:

- Moorabool (MLTS).
- Geelong (GTS).

Option 4B

Option 4B does not included any new 220 kV lines but consist of the uprating of GTS1 and GTS2 220 kV lines, including dynamic rating enablement.

The existing limiting plant requiring replacement to achieve the uprating includes the following:

- GTS2 circuit breaker and disconnector switch at MLTS.
- GTS2 instrumentation at MLTS.
- GTS1 line termination at MLTS.
- GTS1 circuit breaker and disconnector switch at GTS.
- GTS2 circuit breaker and disconnector switch at GTS.

3.3 Project schedule and staging

A high-level indicative staging plan for an assumed commissioning date of December 2033 is presented in Table 3 for Option 3. It is acknowledged that, in line with the VTIF principles, VicGrid has already commenced stakeholder engagement in the south-west REZ.

Table 3 High level schedule and staging

Activity	Indicative range
2024 ISP	To June 2024
Business case[A]	2024 - 2026
Stakeholder engagement	2024 - 2029
Activity	
Environment, land activities and approvals	2026 - 2029
Project development, field investigations and reference design	2026 - 2029
Detailed design	2026 - 2028
Procurement and early contract engagement[B]	2027 - 2029
Construction and commissioning	2028 - 2031
Contingency	2032 – 2033/34

A. Expected to be undertaken by VicGrid as part of the Victorian Transmission Investment Framework process. See https://www.premier.vic.gov.au/better-energy-infrastructure-and-security-victoria.
B. Indicative range subject to delivery approach.

4 Cost estimates (based on preliminary engineering design)

The total procurement costs for each option are provided in the cost estimate provided in Table 4. The AEMO Transmission Cost Database (TCD 2.0 released date 28 April 2023) tool has been used to estimate capital costs for the various project options based on a class 5a cost estimate. The cost estimates for each option are presented as ranges, with the lower end of each range indicating the option estimate with an entire overhead line solution and the higher end of each range indicating the option estimate with a combination of overhead lines and some locations underground cable.

Table 4 SWV1 REZ expansion cost estimate summary

Sub-Option	Estimated capital cost ($m 2022-23)
Option 1A	$669 - $781
Option 1A+	$678 - $790
Option 1B	$962 - $1,145
Option 1C	$1,290 - $1,491
Option 1D	$676 - $787
Option 1E	$1,419 - $1,611 M
Option 2A	$578
Option 2B	$751
Option 2C	$1,490 - $1,684
Option 2D	$1,648 - $1,836
Option 3A	$1,006
Option 3B	$1,239
Option 4A	$39 - $82
Option 4B	$58 - $101

A summary of the risks considered and included in the estimate are presented in 0.The risk types and rating criteria are based on the latest AEMO TCD tool. Business as Usual (BAU) rating incorporates historical project experiences and denotes a risk rating which is indicative of comparable infrastructure projects. A high rating signifies an enhanced element of risk in comparison to projects of a similar scale.

It is pertinent to note that within the TCD tool, risk ratings are inputted for each element and 0 represents an aggregate risk rating for all the design options. A vast majority of included options share an identical risk profile to the aggregate representation showcased below with few minor exceptions.

Table 5 Risk summary

Risk type	Risk rating
Compulsory acquisition	BAU[A]
Cultural heritage	BAU
Geotechnical findings	BAU
Macroeconomic influence	BAU
Market activity	BAU[B]
Outage restrictions	BAU
Project complexity	BAU
Weather delays	BAU
Environmental offset risks	High
Stakeholder and community sensitive region	High

A. Alignments are to be selected to avoid residential properties and compulsory acquisition scenarios where possible. This is reflected in the assigning BAU for compulsory acquisition.
B. Market activity is assumed as BAU based on reasonable predictability for the next five year and AEMO ISP and ESOO predictions. Additionally, labour and material price escalations have been ongoing for some time and could be considered reasonable to continue into the future.

5 Desktop easement and land assessment

In investigating broad conceptual transmission corridors, AVP recognises the potential to minimise impacts through co-locating new linear infrastructure with existing transmission infrastructure, either within established easements, or as close as practicable. A minimum distance would need to be maintained between new and existing infrastructure where lines are proposed to be co-located.

Option 1 (and sub-options) has the largest extent of existing transmission lines, stretching from Portland to Sydenham with varying easement widths. Double circuit 500 kV transmission lines currently exist between Portland and Moorabool. Two 500 kV single circuit transmission lines exist between Moorabool and Sydenham with two single 220 kV transmission lines from Moorabool to Deer Park in proximity.

Opportunities to co-locate transmission in Option 2 are limited, as no transmission lines currently exist between Mortlake and Bulgana except for 66kV sub-transmission lines to and from wind farms.

Any transmission north of Heywood to the proposed Bulgana Terminal Station would be in a greenfield (no existing transmission lines) environment. Transmission lines exist around Hamilton, though co-location may not be feasible because the direction of transmission would not follow an alignment to Bulgana. `

Option 4A partially could allow a new single circuit line to follow an existing easement south from Moorabool Terminal Station, but an overhead alignment would be severely constrained around Lovely Banks due to existing built areas with residences. Areas north and south are likely to further constrain opportunities for new overhead transmission because of areas of land are identified for future potential housing supply. Alternate options to overhead transmission are very likely to need to be explored, including assessing the potential for underground cabling in parts, or exploring other feasible network upgrades to achieve the optimal network solution. This may include minor augmentations to optimise existing line ratings, use of control schemes, or power flow controllers (all subject to further investigation as to their feasibility).

Minor changes are proposed at each terminal station to accommodate new transmission lines and new switch bays where needed. AVP anticipates any changes could largely be accommodated within existing terminal station footprint.

AVP recognises constructing new transmission needs to be carefully considered and should explore what benefits or disadvantages exist in the context of greenfield or brownfield environments. Any decision to invest in new transmission will be supported by extensive and detailed investigations on environmental, cultural, social, land impacts, and comprehensive stakeholder engagement to fully assess social and environmental feasibility.

VicGrid is anticipated to be given legislative powers from early 2024 to plan major transmission augmentations and the development of REZs in Victoria. Further planning for REZs across Victoria (including the SWV1) will occur through the Victorian Transmission Plan process which will inform future ISP development. While the current analysis only includes initial desktop analysis of land use and local stakeholder considerations, further, more detailed analysis to support REZ development in Victoria (including the SWV1) will be undertaken as part of the Victorian Transmission Investment Framework (VTIF) process.

6 Preliminary assessment of environmental and planning approvals and stakeholder engagement

AVP undertook a high-level assessment of the potential environmental, social, cultural, and land impacts for the transmission options identified (outlined below). In summary, this desktop assessment identified substantial constraints and high levels of risk that will likely need to be mitigated in order to obtain the social and environmental approval for the project to proceed. In the event a future ISP nominates a transmission option in the SW REZ for further investigation, extensive environmental, cultural and land assessments and comprehensive meaningful stakeholder engagement would be required to fully assess its social and environmental feasibility and build community understanding and support.

AVP investigated corridors that could host a potential transmission augmentation, using publicly available information to understand environmental and social constraints at a desktop level. AVP identified broad conceptual corridors for each augmentation option:

- From Portland to Sydenham encompassing existing or planned terminal stations (all sub-options to Option 1).
- Heywood (Option 3A and 3B) or Mortlake (Option 2A and 2B) north to proposed Bulgana terminal station[6].
- South of Moorabool terminal station to Geelong terminal station in Norlane (Option 4A).

This high level assessment identified numerous environmental and social constraints with the potential for significant environmental and social impacts that require further studies to assess the feasibility of options, such as:

- The presence of geographical areas (world heritage properties / national parks) that are typically avoided when developing a transmission alignment.
- The potential close proximity of socially and culturally significant areas such as the UNESCO World Heritage Budj Bim Cultural Landscape and the Grampians National Park.
- The absence of existing infrastructure in the vicinity of options 2 and 3 to enable co-location.
- The proximity of existing dwellings in some locations and areas identified for new housing supply.
- The potential presence of vegetation communities and/or threatened flora and fauna with significance at Commonwealth or State levels.
- The absence of existing linear transmission infrastructure in the vicinity of options 2 and 3 (greenfield environments) that may provide an ability to enable the co-location of transmission infrastructure to Bulgana.
- The cumulative social and environmental impacts, including the level of social capacity of the south west community to host more transmission infrastructure given the substantial amount of new renewable development that has occurred in the region over more than two decades and what is already planned and proposed over the coming years.

[6] General location of proposed terminal station.

While direct stakeholder engagement has not been undertaken as part of these preparatory activities, the long-held social and environmental concerns about the burden of hosting even more renewable infrastructure in the south west is well known, and has understandably led to calls for better integrated planning, fairer community benefit sharing to offset impacts, and more meaningful and genuine stakeholder engagement. These calls are echoed across communities throughout Victoria who are being asked to host transmission infrastructure to help enable the transition to renewable generation.'.

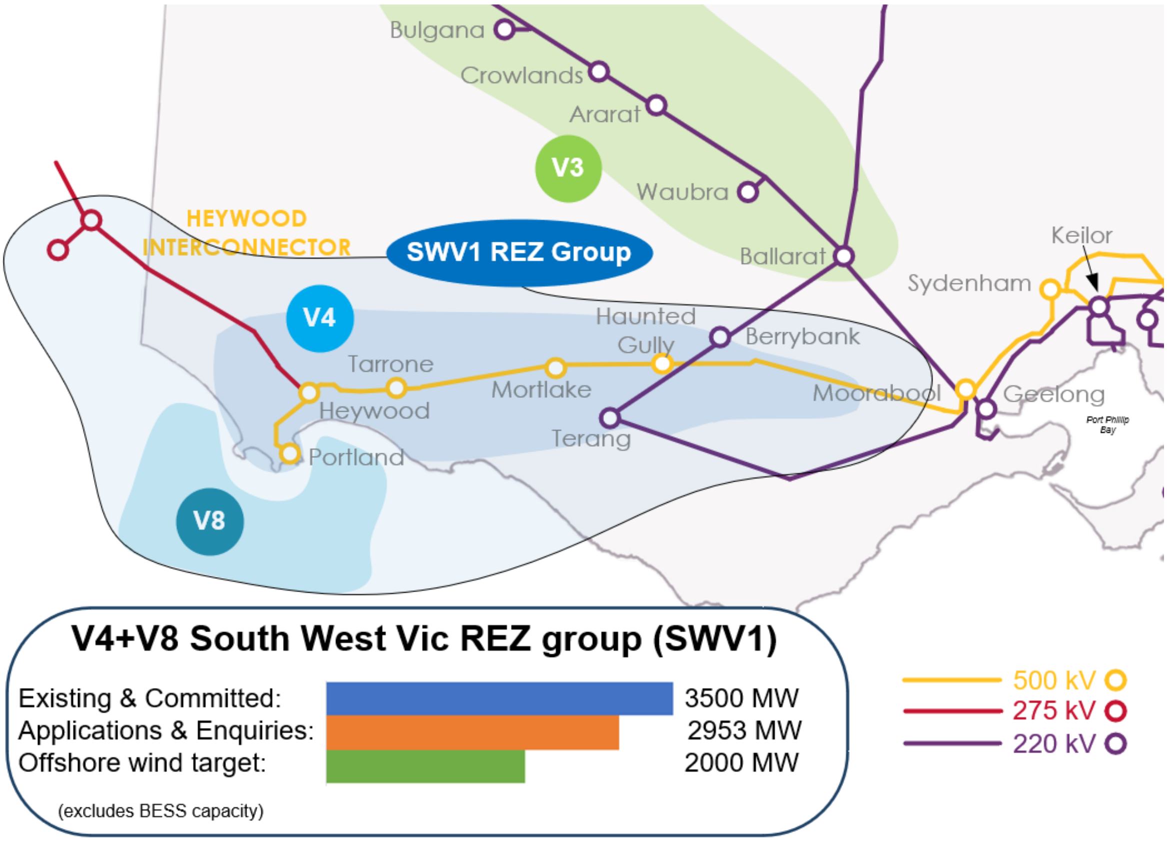
AVP is committed to working with VicGrid regarding best practice engagement to help facilitate an environmentally, economically and socially sustainable energy system. AVP recognises that the prospect of any additional transmission project is challenging for communities. If in the event a future ISP nominates a transmission option in the SW REZ, a comprehensive engagement plan would be prepared that involves Traditional Owners, potential host landowners, neighbours, local communities, LGAs, consumer advocates, industry and interest groups and federal, state and local government authorities. This engagement plan would be developed in collaboration with VicGrid and key stakeholders and will continue to evolve to ensure it meets the needs, preferences of stakeholders and any transitional arrangements that may be associated with VTIF to support REZ development in SWV1

Stakeholder engagement about the project's social and environmental feasibility would run parallel with developing and refining a transmission alignment if a project were to be identified in a future ISP. Specialist technical investigations and assessments would be undertaken, and any findings to avoid impacts carefully considered. Identification of alternate options for any transmission alignment based on stakeholder feedback or technical investigations would be evaluated and inform planning and environmental approvals. Given the length of line contemplated for each option overlaps multiple planning schemes or Registered Aboriginal Party areas, there is potential for a planning scheme amendment and cultural heritage management plan(s).

AVP completed preparatory activities for environment and stakeholder constraints at a desktop level only with no supporting field investigations and represents a point in time where information or decisions about SW Vic REZ Expansion may change. As part of VTIF implementation, it is anticipated that VicGrid will utilise this desktop analysis. This is expected to be an iterative process of more detailed analysis to support REZ development in SWV1.

7 REZ transfer capacities

Figure 3 Summary of existing capacity and connections pipeline in Victoria



The current REZ transmission limit[7] for the south-west VIC REZ is 1,700 MW (Draft 2023 TEOR). This is currently limited by voltage stability which is expected to be lifted above thermal limits following commissioning of the RDP1 Mortlake turn-in project.

The total in-service and committed generation has an installed capacity of 3,500 MW, as shown in Figure 3 above. There is also up to 2,953 MW of connection applications and enquiries in the SWV1 area. The Victorian Government also has an offshore wind target of at least 2 GW by 2032 in the Gippsland and Portland areas.

This brings total in-service, committed and future interest of generation capacity in south-west Victoria to somewhere between 6,453 MW and 8,453 MW (depending on how much of the targeted 2 GW of offshore wind by 2032 is planted in the Portland area). Excluding existing and committed 220 kV wind capacity along the Ballarat – Berrybank – Terang – Moorabool 220 kV corridor (which has separate network constraints to 500 kV capacity), this is a total of between 5,722 and 7,722 MW of existing, committed and future interest of installed

[7] Maximum MW output achievable from all generators and interconnectors within the REZ for N-1 conditions, exporting east out of the REZ towards VIC and NSW load centres (assuming 45 degrees C temperatures for critical lines). REZ transfer capacity MW values may be different under a different definition of the REZ transmission limit.

generation capacity on the 500 kV network in South-West Victoria (including 584 MW of existing gas-powered generation at Mortlake Power Station).

The ISP's draft 2023 *Transmission Expansion Options Report* considered options to unlock transfer capacity for the SWV1 group, which consists of the V4 (SW-VIC onshore) and V8 (SW-VIC offshore) REZs, as well as the VIC-SESA Heywood interconnector. Likewise, this preparatory activities report presents options to increase transfer capacity for the SWV1 group, to unlock MW levels of generation within this group as anticipated and as indicated by the figures outlined above. It is important to note that while the options presented are to unlock transfer capacity to serve load outside of the SWV1 REZ group, there is load within the REZ group in the Portland area that can be served locally as well.

Power system studies were undertaken to assess the network limitations that may constrain supply in SWV1 in exiting the REZ group (towards Victoria and New South Wales[8]) and therefore dictate the SWV1 REZ group MW transmission limit[7].

Note that in the studies, only the existing and committed generation were modelled specifically. Additional MW output beyond existing and committed generators' capability was modelled via 2 planting scenarios:

- Onshore representation of future generation at Mortlake Terminal Station.
- Offshore representation of future generation at new terminal station near APD.

Where future generation connects to the network in areas different to the above assumption, the options presented may need to be adjusted to ensure MW transfer capacity unlocked reaches the connection point(s) of this generation.

The following details the core assumptions used in studies to develop an indicative MW transfer limit for each SWV1 expansion option that may be used in ISP DLT modelling:

- High VIC demand (approximately 9,400 MW OPGEN).
- All industrial loads at full capacity.
- Heywood importing approximately 340 MW into Victoria, and Heywood and EnergyConnect flows balanced via use of the Buronga Phase Shifting Transformers (PSTs).
- High VIC to NSW transfer (approximately 1,700 MW).
- V3 Western Victoria REZ generation at approximately 960 MW.
- V4 south-west Victoria existing and committed wind farms along:
  - 220 kV network from BATS-BBTS-TGTS-MLTS generating 230 MW.
  - 500 kV network from Heywood to Mortlake/Haunted Gully to Moorabool generating 2,750 MW.
- Following committed, anticipated, and actionable projects modelled (as per the NEM Transmission Augmentation Information December 2022 workbook):
  - VNI Minor.
  - EnergyConnect – Stages 1 and 2.

[8] This assumes imports from SESA-VIC, where the MW import is included as part of the total SWV1 MW output towards Victoria. It is assumed that any reduction in imports from SESA-VIC would allow an equal increase in MW output from SWV1 generation, and the SWV1 MW transfer limit would remain unchanged.

  - RDP - Mortlake turn-in project.
  - RDP - south-west Victoria REZ minor augmentations.
  - WRL, including the 500 kV uprate to Bulgana.
  - HumeLink.
  - VNI West (Option 5A), the preferred option in the Project Assessment Conclusions Report.
- 45D temperatures for critical 500 kV lines from SWV1 to Melbourne.
- New generator connections in SWV1 group assumed to have reactive capability of approximately 15% of MW capacity.

To further understand the different limitations that SWV1 supply may be subjected to under different conditions, a number of assumptions in these studies were varied.

These assumptions included:

- MW output of V3 Western Victoria REZ generation, for existing and committed generation on the 220 kV network, and for new assumed generation at Bulgana 500 kV.
- VIC-NSW export levels.
- VIC regional demand levels.

The following tables outline the MW transfer capacity for SWV1 group for the options tested in these preparatory activities for the core assumptions outlined above (the MW transfer capacity being the total MW output of generators in SWV1 plus the MW import from SESA-VIC on the Heywood interconnector, flowing toward Victorian load centres and New South Wales). These tables also indicate the limiting network constraint for the SWV1 group, and detail other network constraints that may result in bottlenecks between SWV1 supply and load centres elsewhere depending on system conditions. The MW transfer capacity and limiting constraints may be impacted by changes in assumptions used, such as the output from generation in other areas that compete for the same corridors, or the amount of exports or imports from or to Victoria. The section below discusses these impacts.

The tables reflect two future generation planting scenarios for the MW transfer capacity studies:

- Onshore future generation (V4 REZ) – 100% connected at Mortlake Power Station.
- Offshore future generation (V8 REZ) – 100% connected at or near existing APD site.

Regarding the “other identified network constraints” detailed in these tables, it is recommended that constraints are developed for inclusion in the ISP modelling, to better understand whether these constraints should be augmented as part of the core SW-VIC expansion options. The anticipated minimum required augmentations, based on the core assumptions used, are also shown in these tables.

Table 6 SWV1 transfer capacity with onshore future generation

Option	SWV1 transfer capacity (MW)	Critical network constraint	Other identified network constraints	Anticipated minimum additional requirements[A]
Status quo	3,900	CRTSB-MLTS 500 kV overload for trip of parallel CRTS-MLTS 500 kV	Thermal overload of: MLTS-GTS 220 kV for trip of parallel line GTS-DPTS 220 kV for trip of DPTS-KTS 220 kV or SYTS-KTS 500 kV	Option 4A, 4B or equivalent non-network solutions.
1A	4,850 (+950)	MLTS-SYTS 500 kV overload for trip of parallel line		
1A with upratings	5,400 (+1,500)	MLTS-SYTS 500 kV overload for trip of parallel line		
1B	5,650 (+1,750)	CRTS-MLTS 500 kV overload for trip of parallel CRTS-MLTS 500 kV		
2A	5,850 (+1,950)	CRTS-MLTS 500 kV overload for trip of parallel CRTS-MLTS 500 kV		
2B	6,800 (+2,900)	CRTS-MLTS 500 kV overload for trip of parallel CRTS-MLTS 500 kV		
2C	7,650 (+3,750)	CRTS-MLTS 500 kV overload for trip of parallel CRTS-MLTS 500 kV	Same as above, plus: SYTS-KTS 500 kV for trip of NSYTS-SMTS 500 kV KTS 500/220 kV for trip of ROTS-SMTS 500 kV GTS-KTS 220 kV for trip of SYTS-KTS 500 kV	
2D	8,600 (+4,700)	CRTS-MLTS 500 kV overload for trip of parallel CRTS-MLTS 500 kV		

A. Regarding the "other identified network constraints", based on core study assumptions used.
B. Cressy Terminal Station.

Table 7 SWV1 transfer capacity with offshore future generation

Option	SWV1 transfer capacity (MW)	Critical network constraint	Other identified network constraints	Anticipated additional requirementsError! Bookmark not defined.
Status quo	3900	APD-HYTS 500 kV overload for trip of MOPS-APD 500 kV Or CRTS-MLTS 500 kV overload for trip of parallel CRTS-MLTS 500 kV	Thermal overload of: DPTS-GTS 220 kV for trip of DPTS-KTS 220 kV or SYTS-KTS 500 kV MLTS-GTS 220 kV for trip of parallel line	Option 4A, 4B or equivalent non-network solutions.
1D	4850 (+950)	MLTS-SYTS 500 kV overload for trip of parallel line		
1E	5650 (+1750)	CRTS-MLTS 500 kV overload for trip of parallel CRTS-MLTS 500 kV		
3A	5700 (+1800)	CRTS-MLTS 500 kV overload for trip of parallel CRTS-MLTS 500 kV		
3B	6700 (+2800)	CRTS-MLTS 500 kV overload for trip of parallel CRTS-MLTS 500 kV		

7.1 Impact from varied assumptions

As highlighted earlier, the MW transfer capacity and limiting constraints may be impacted by different system conditions. Studies looking at these different system conditions have indicated the following.

For changes in V3 generation

For all options:

- Increases in V3 generation specifically on the 220 kV network result in:
  - Increased loading on the BATS-WBTS 220 kV line for a trip of the BGTS-CWTS 220 kV line, where V3 generation may be constrained due to this limitation.
  - Increased loading on the BATS-BETS 220 kV line for a trip of the BGTS-CWTS 220 kV line or the KGTS-BETS 220 kV line (depending on system conditions).
- Increases in V3 generation on both the 220 kV and 500 kV[9] network result in:
  - increased loading on the MLTS-GTS-DPTS[10]-KTS 220 kV, SYTS-KTS 500 kV, KTS 500/220 kV, MLTS-SYTS 500 kV, SYTS-SMTS 500 kV lines. Increases in SWV1 generation also increases loading on these lines, and therefore SWV1 and other western-Victoria generation may be constrained at times due to these limitations in future.

For status quo and option 1 sub-options:

- Where the critical limitation on SWV1 output is CRTS-MLTS 500 kV for trip of parallel CRTS-MLTS 500 kV line, it appears that increased V3 output does not impact the SWV1 MW transfer capacity, as the two REZs do not compete along that corridor. Where the critical limitation on SWV1 output is MLTS-SYTS 500 kV for trip of parallel line, increases in V3 output do impact the loading and hence the MW transfer capacity of SWV1.

For option 2 and 3 sub-options:

- Same as above, except V3 output does compete with V4 output on the CRTS-MLTS 500 kV lines, given the two REZs are linked west of these lines through these options. Therefore where CRTS-MLTS 500 kV for trip of parallel line is the critical constraint, increases in V3 output can impact the SWV1 group transfer capacity.

Impact of higher VIC-NSW exports coincident with lower Victorian regional demand

For all options:

- Increased loading on VNI corridors, particularly the BATS-BETS 220 kV line.
- Reduced loading on metropolitan corridors supplied by western Victoria generation, including MLTS-GTS-DPTS-KTS 220 kV, SYTS-KTS 500 kV, and KTS 500/220 kV elements.

For status quo and option 1 sub-options:

- Minimal impact on SWV1 MW transfer, where the limiting constraints (such as CRTS-MLTS 500 kV and MLTS-SYTS 500 kV lines) are still fully utilised in exporting MW flow from the SWV1 REZ group.

For option 2 and 3 sub-options:

- Reduced loading on SWV1 limiting constraints (such as CRTS-MLTS 500 kV and MLTS-SYTS 500 kV lines), as more flow exits the SWV1 group via the SWV1 to Bulgana 500 kV corridors. This would result in higher SWV1 MW transfer capacity.

[9] future connections assumed at Bulgana 500 kV built as part of WRL/VNIW

[10] At a certain combined V3 and V4 output level, a shift in critical contingency for DPTS-GTS 220 kV overload to MLTS-SYTS 500 kV or SYTS-KTS 500 kV, at which point more V3 output results in higher DPTS-GTS 220 kV loading. Below this combined V3 and V4 level, DPTS-GTS 220 kV loading remains static for changes in output in either of these REZs (where the critical contingency is DPTS-KTS 220 kV and the primary driver for loading is DPTS local load)

A1. Single line diagrams

Figure 4 Single line diagram (Option 1A)

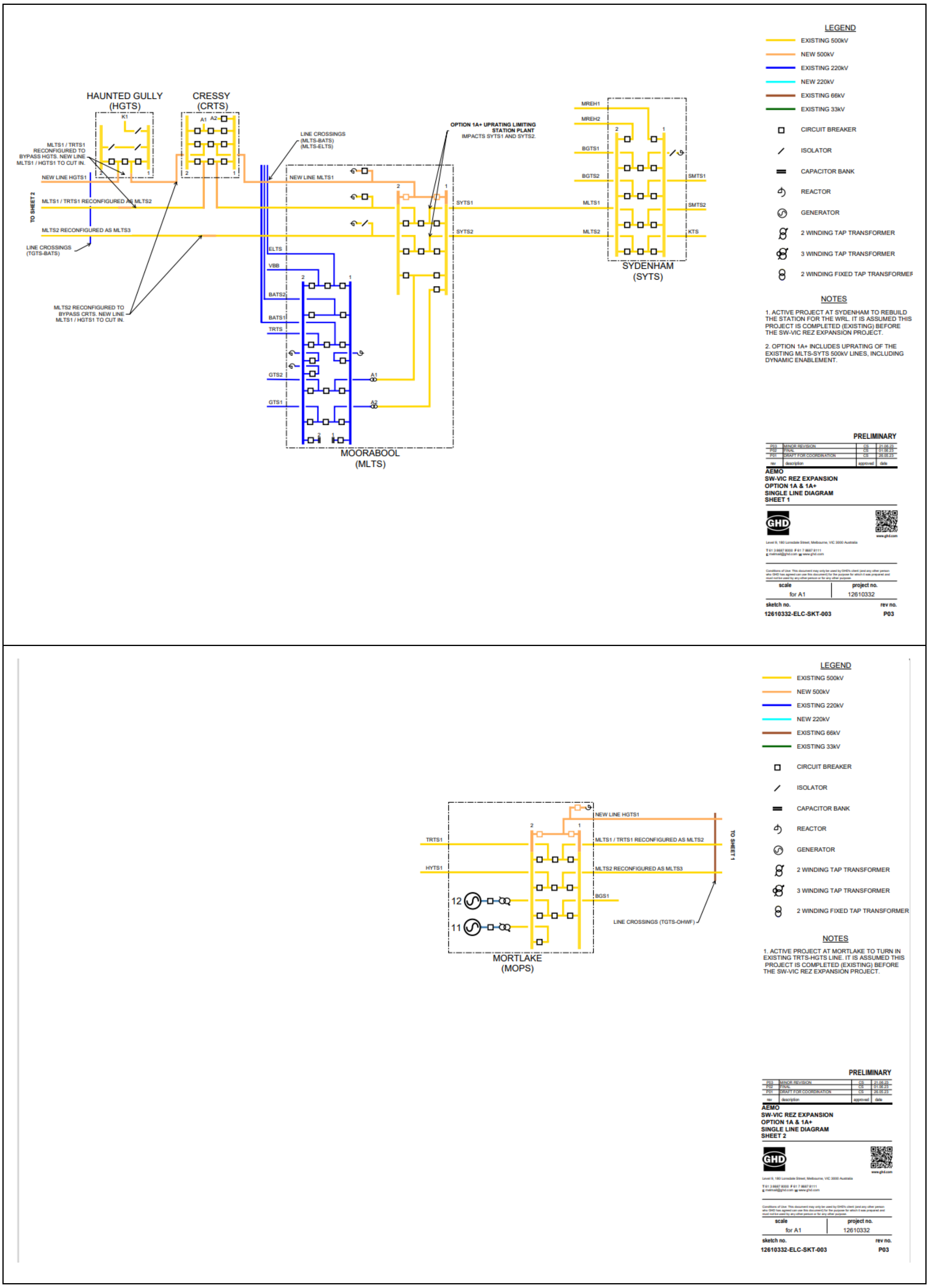


Figure 5 Single line diagram (Option 1B)

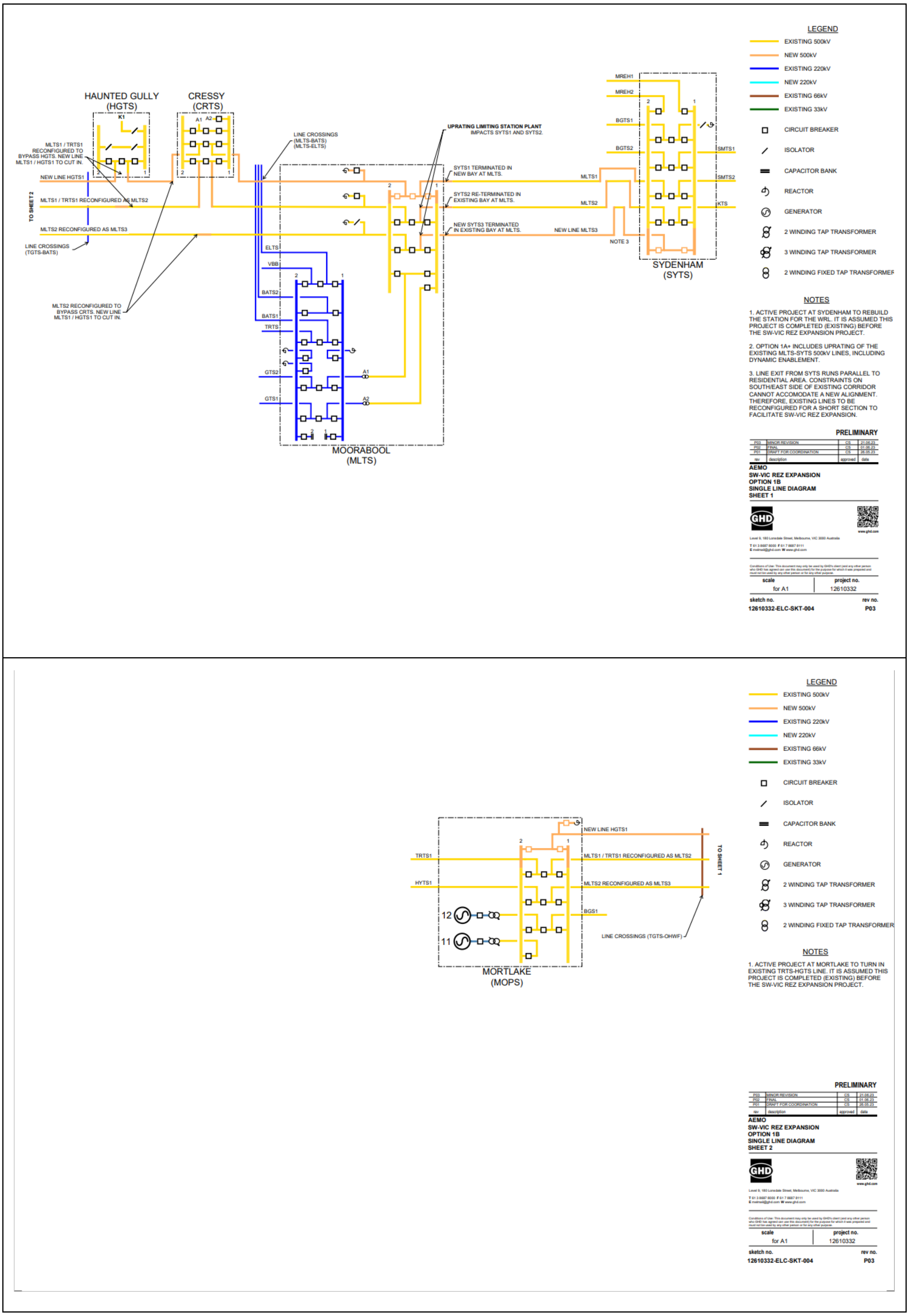


Figure 6 Single line diagram (Option 1C)

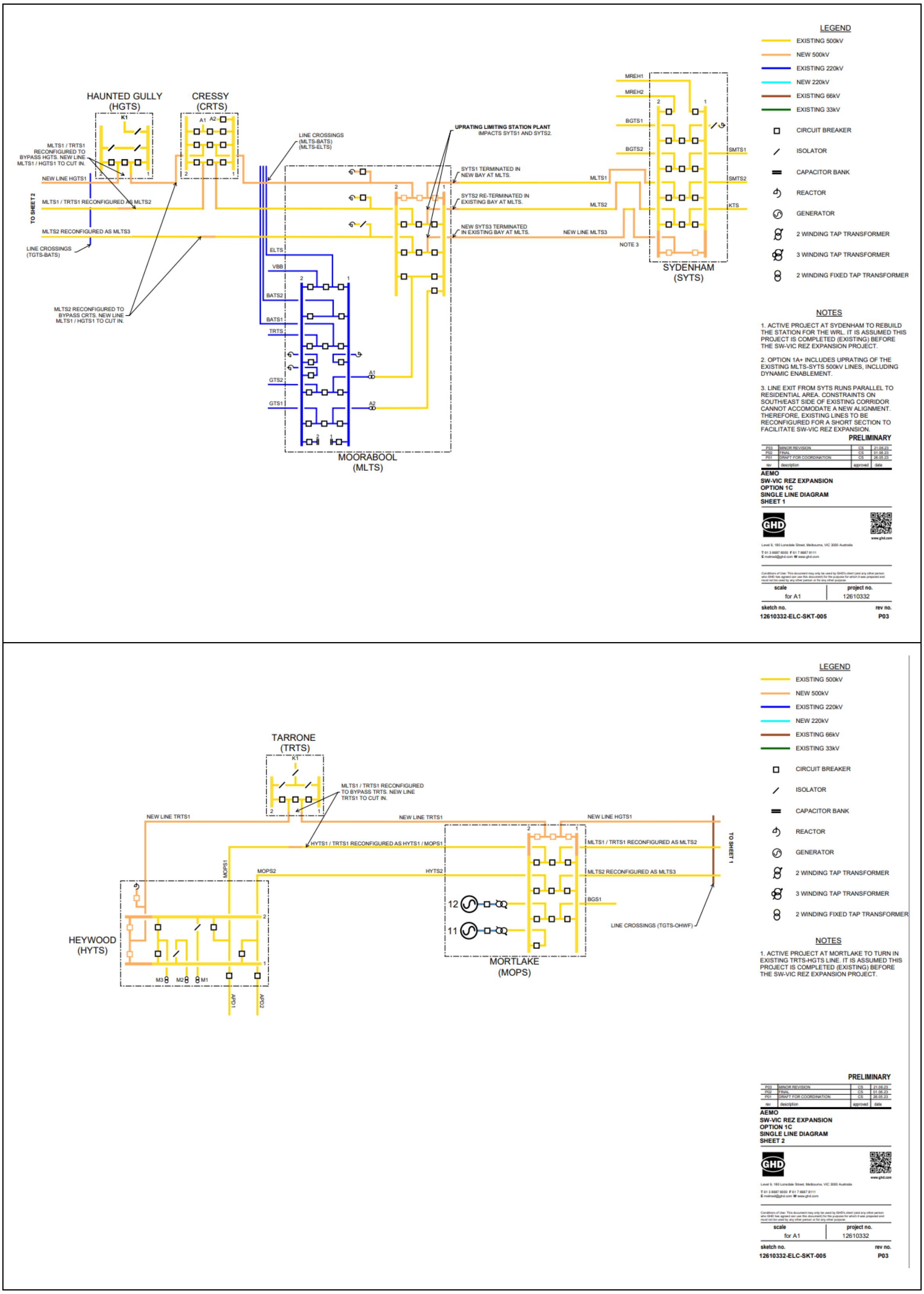


Figure 7 Single line diagram (Option 1D)

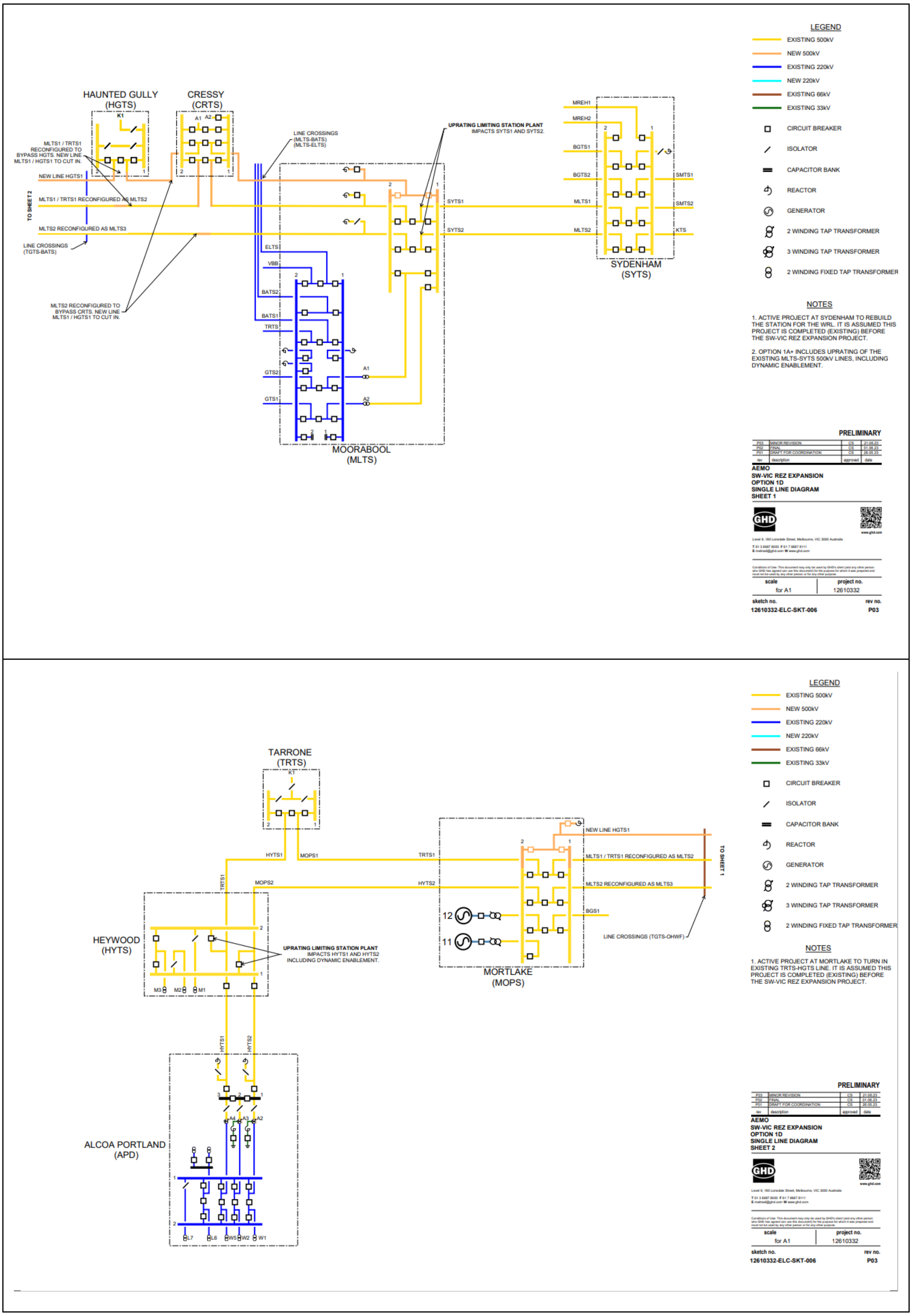


Figure 8 Single line diagram (Option 1E)

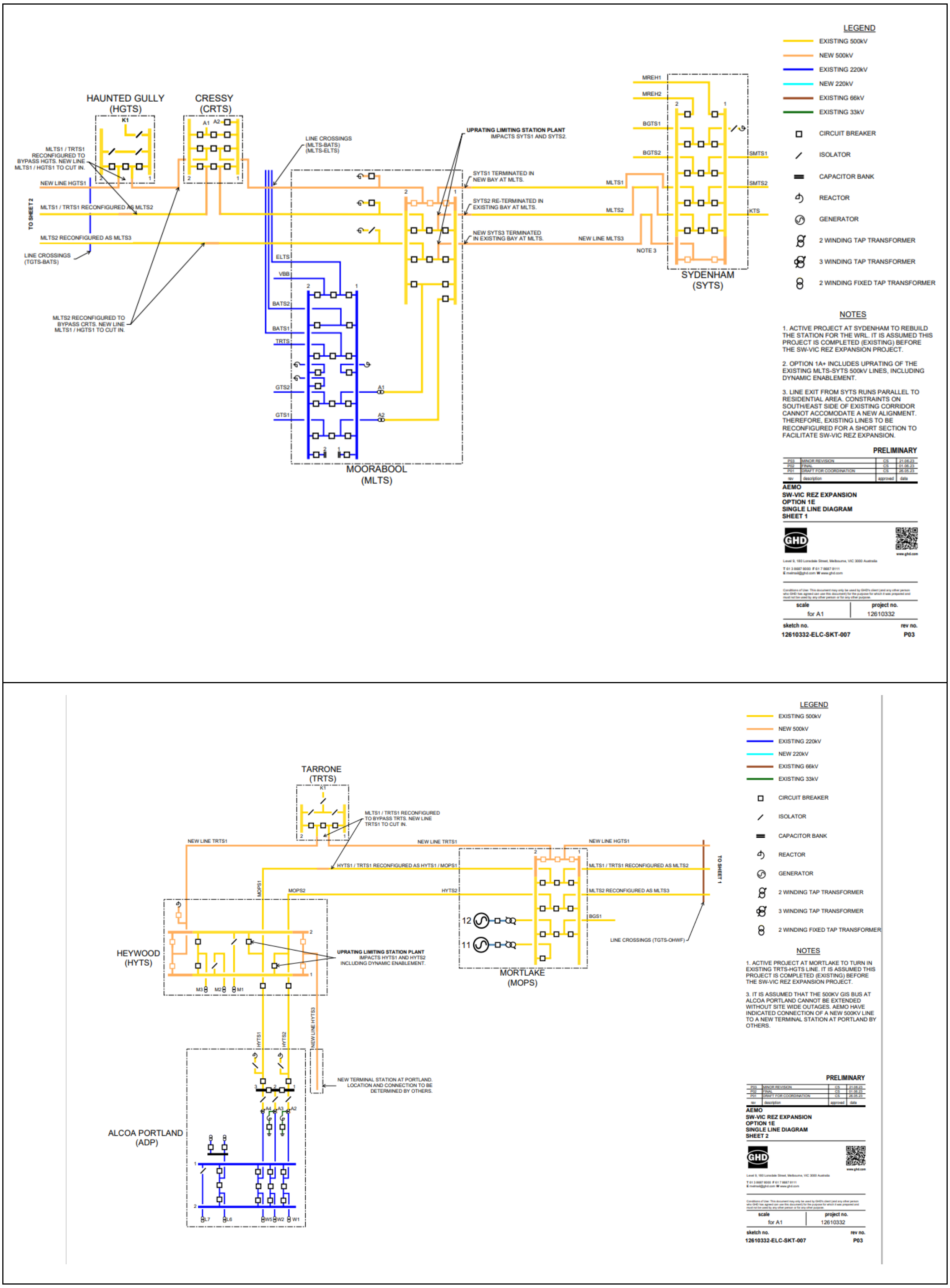


Figure 9 Single line diagram (Option 2A)

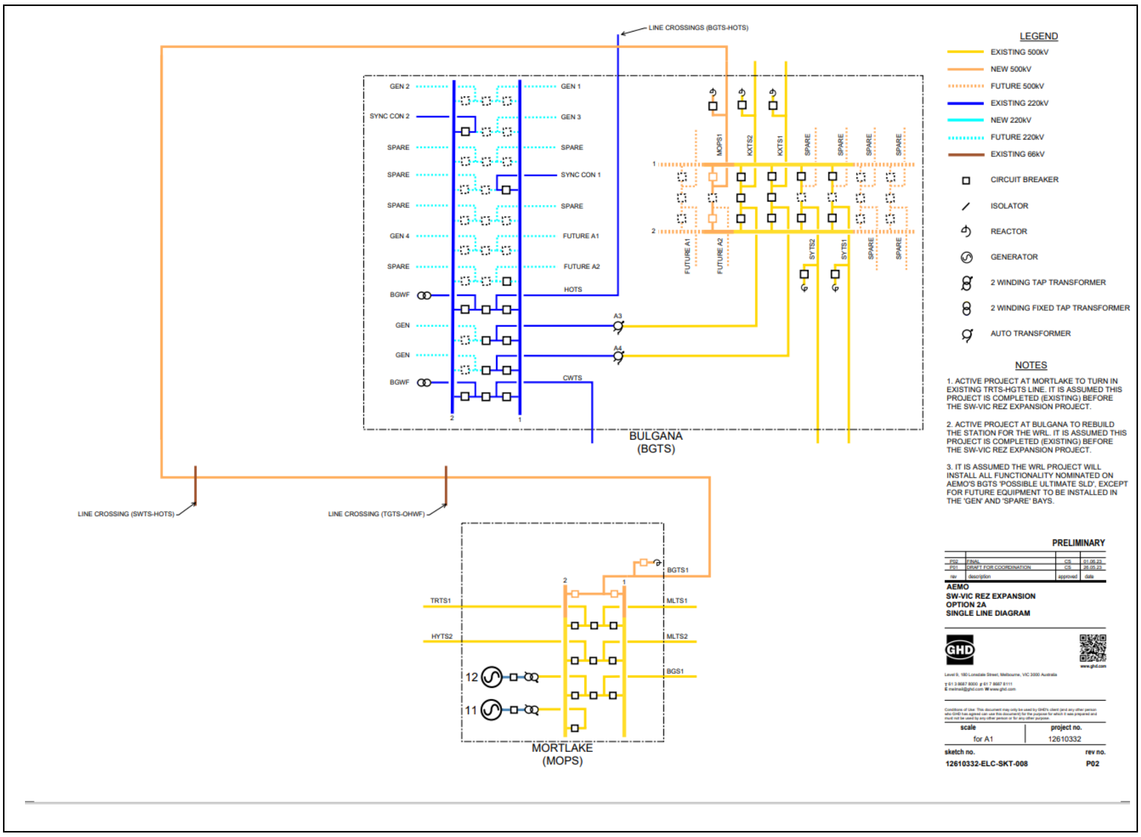


Figure 10 Single line diagram (Option 2B)

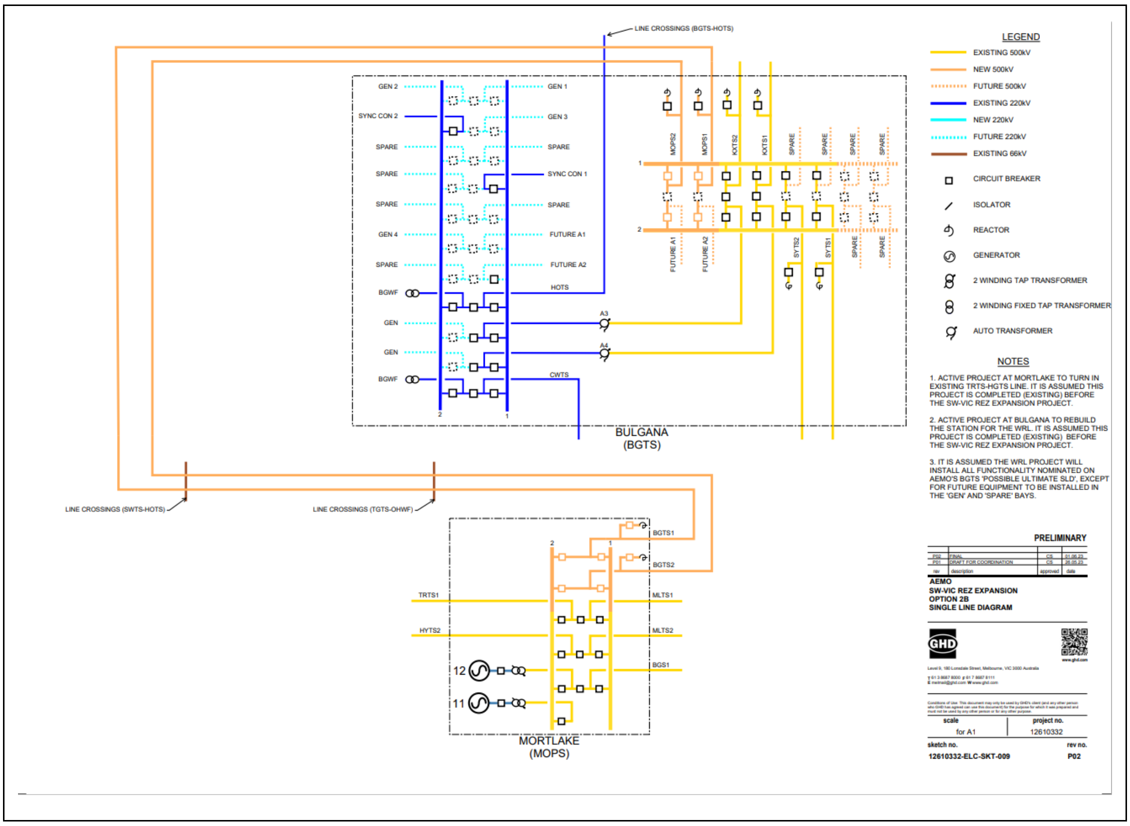


Figure 11 Single line diagram (Option 2C)

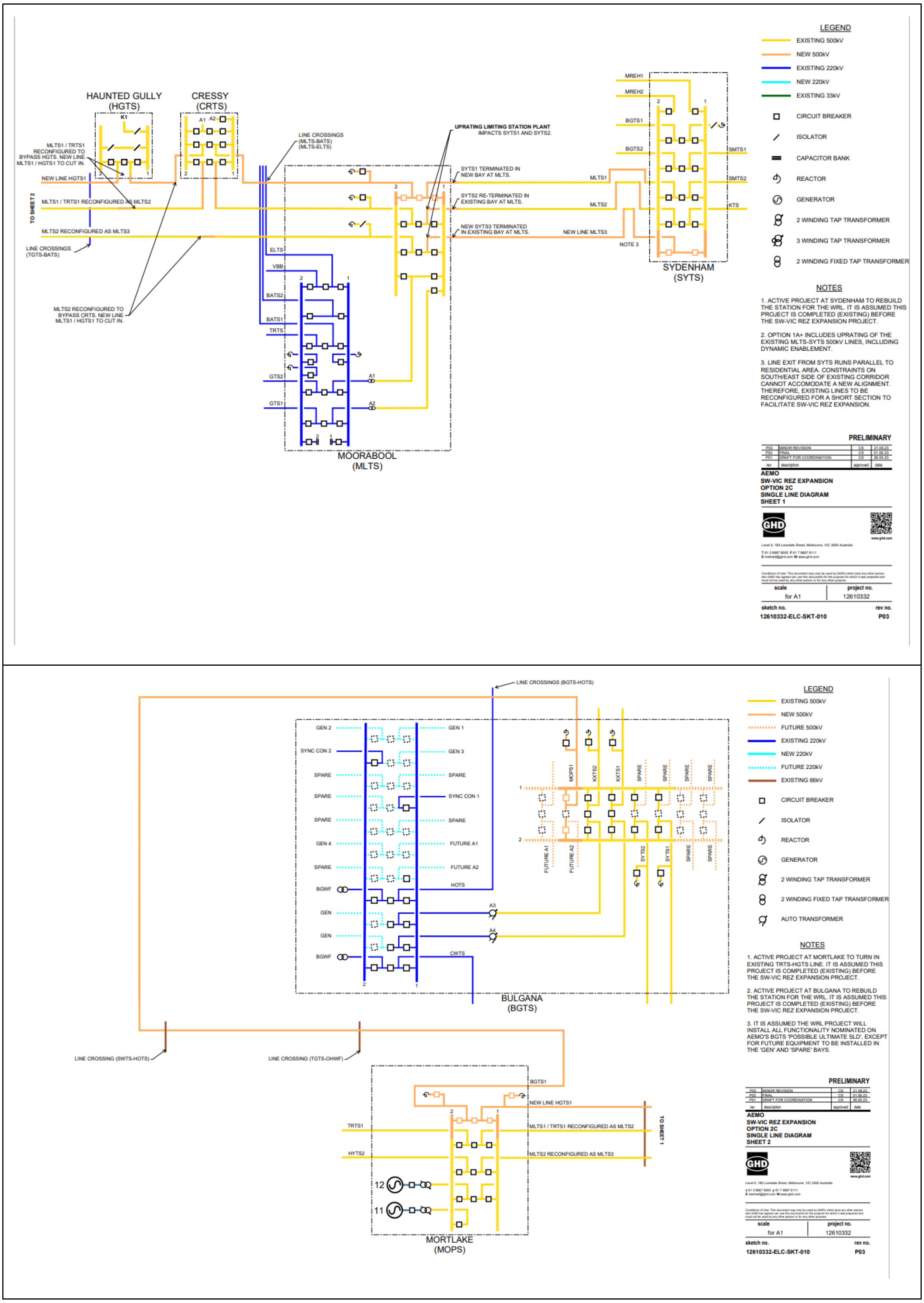


Figure 12 Single line diagram (Option 2D)

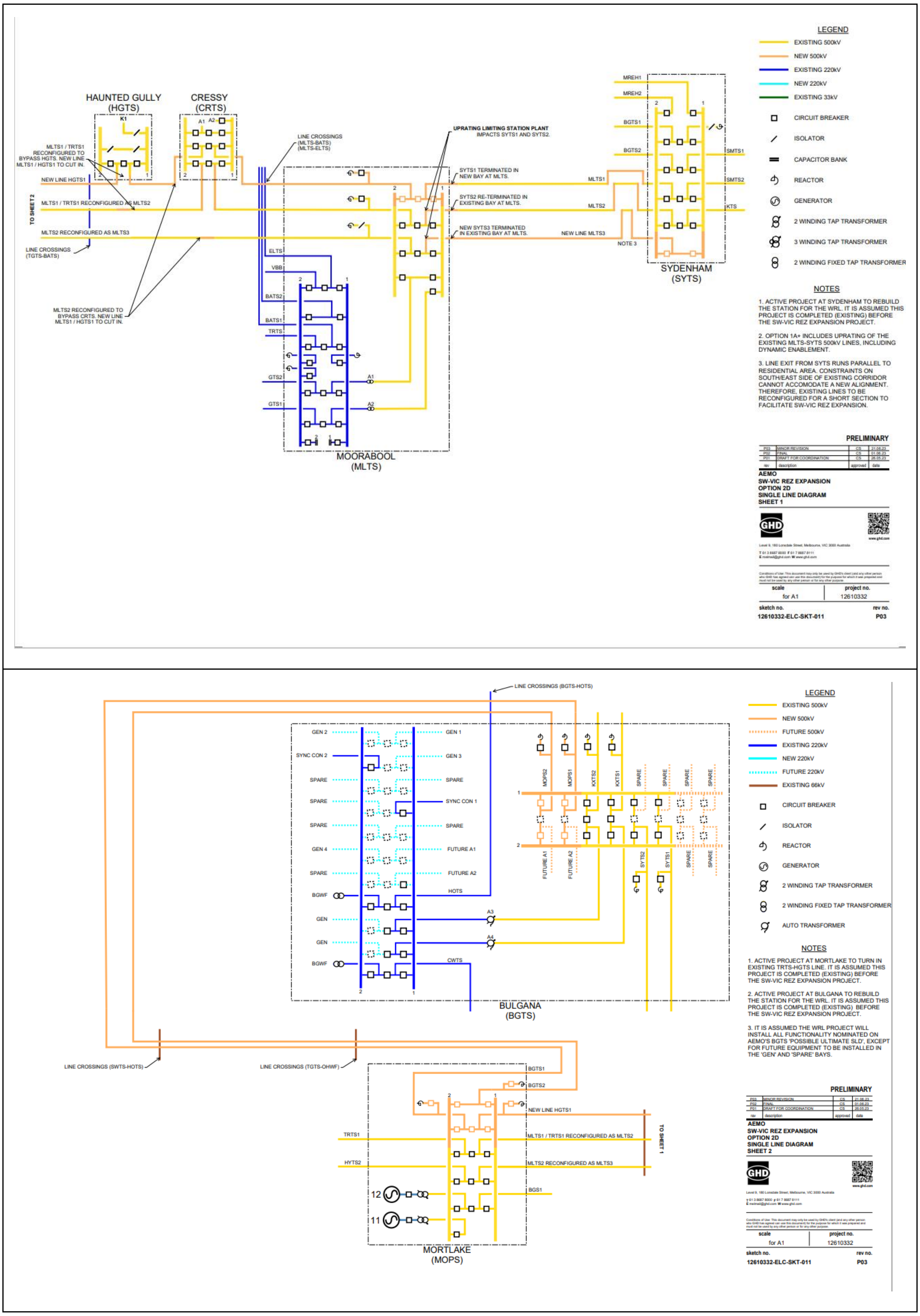


Figure 13 Single line diagram (Option 3A)

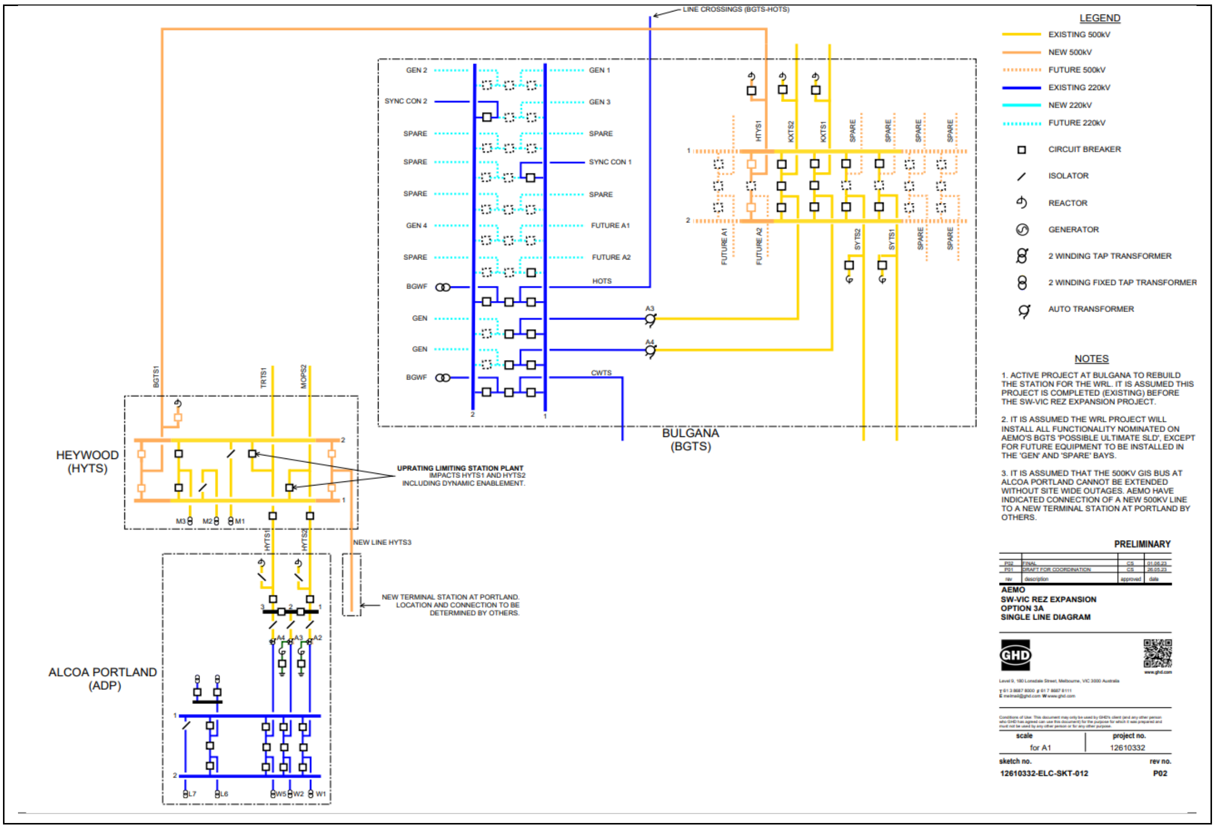


Figure 14 Single line diagram (Option 3B)

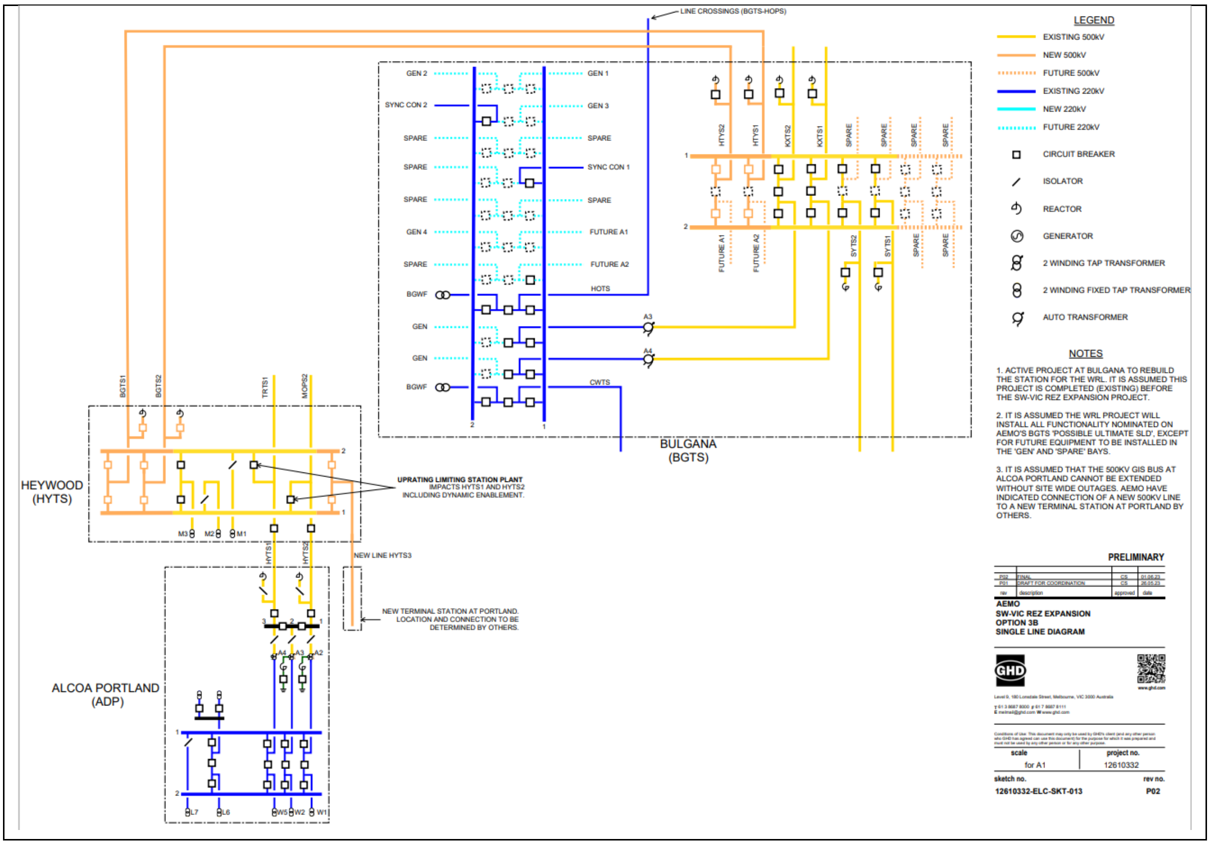


Figure 15 Single line diagram (Option 4)