Victorian Planning

Victorian Annual Planning Report

October 2024

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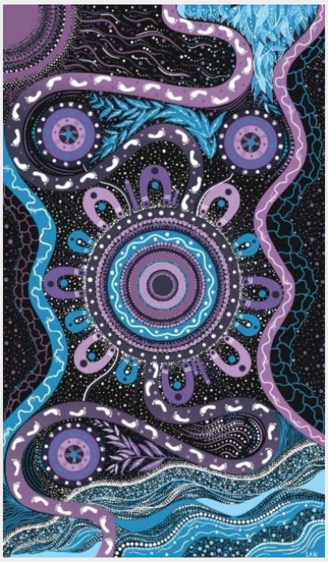

We acknowledge the Traditional Custodians of the land, seas and waters across Australia. We honour the wisdom of Aboriginal and Torres Strait Islander Elders past and present and embrace future generations.

We acknowledge that, wherever we work, we do so on Aboriginal and Torres Strait Islander lands. We pay respect to the world's oldest continuing culture and First Nations peoples' deep and continuing connection to Country; and hope that our work can benefit both people and Country.

'Journey of unity: AEMO's Reconciliation Path' by Lani Balzan

AEMO Group is proud to have launched its first Reconciliation Action Plan in May 2024. 'Journey of unity: AEMO's Reconciliation Path' was created by Wiradjuri artist Lani Balzan to visually narrate our ongoing journey towards reconciliation - a collaborative endeavour that honours First Nations cultures, fosters mutual understanding, and paves the way for a brighter, more inclusive future.

Important notice

Purpose

The purpose of this publication is to provide information relating to electricity supply, demand, network capability, and development for Victoria's electricity transmission declared shared network.

AEMO Victorian Planning (AVP) publishes the Victorian Annual Planning Report (VAPR) in accordance with clause 5.12 of the National Electricity Rules. This publication is generally based on information available to AVP as at 30 June 2024, although AVP has incorporated more recent information where practical.

Disclaimer

AEMO has made reasonable efforts to ensure the quality of the information in this publication, but cannot guarantee that information, forecasts, and assumptions are accurate, complete or appropriate for your circumstances.

Modelling work performed as part of preparing this publication inherently requires assumptions about future behaviours and market interactions, which may result in forecasts that deviate from future conditions. There will usually be differences between estimated and actual results, because events and circumstances frequently do not occur as expected, and those differences may be material.

This publication does not include all of the information that an investor, participant, or potential participant in the National Electricity Market might require and does not amount to a recommendation of any investment. Anyone proposing to use the information in this publication (which includes information and forecasts from third parties) should independently verify its accuracy, completeness and suitability for purpose, and obtain independent and specific advice from appropriate experts.

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Executive summary

The 2024 *Victorian Annual Planning Report* (VAPR) presents AEMO Victorian Planning's (AVP's) annual 10-year Transmission Development Plan for Victoria. The 2024 plan reiterates the need to progress key transmission projects to deliver the necessary infrastructure to enable the energy transition and maximise benefits to Victorian household and business consumers.

Planned network investments – including projects in delivery or development – help reduce overall costs to consumers by unlocking lower-cost generation supplies, enhancing competition, increasing power system resilience, and improving the efficiency of resource sharing between Victoria and neighbouring regions in the National Electricity Market (NEM).

The rapid changes in Victoria's energy landscape are driven by consumer choices, energy market participant choices, and state and federal government policies and regulations. **The main changes shaping the state's transmission needs over the next decade are**:

- **The geographic location of supply continues to diversify.** Historically, Victoria's electricity largely came from large brown coal generators in the Latrobe Valley, in the east of the state. Now, and increasingly in future, supply comes from renewable resources and interconnectors throughout Victoria.
- **The latest forecasts indicate higher electricity maximum demand for the next five years.** This is driven by homes and businesses switching from gas to electricity, and a forecast increase in demand from data centres.
- **Minimum demand from the grid continues to decline.** As consumers' distributed photovoltaic (PV) investments keep growing and meeting more of their energy needs, the low and declining levels of grid demand create a range of challenges to ensure secure operation of the power system.

The 2024 VAPR and Transmission Development Plan for Victoria are largely consistent with last year's assessment, **reinforcing that continued progress on a suite of projects across the state is critically important to alleviate constraints in Victoria's Declared Shared Network (DSN) and deliver consumer benefits**. These projects include:

- Western Renewables Link (WRL), Victoria – New South Wales Interconnector West (VNI West), and Renewable Energy Zone (REZ) Development Plan (RDP) Stage 1, which are all advancing to detailed design and delivery stages.
- Planned projects which are still undergoing regulatory investment tests for transmission (RIT-Ts), scoping and/or approvals, include reactive power management, provision of system strength, reinforcing eastern Victoria and western metropolitan Melbourne, and reconfiguration of the Latrobe Valley.

AVP continues to progress these planned projects, so they can be delivered in a timely manner to manage power system security and provide Victorian consumers with reliable energy at the lowest cost.

The 2024 VAPR demonstrates the importance of delivering key infrastructure projects to manage Victoria's reliability and system security risks

Victoria's transmission planning is driven by the context of rapid changes in the energy landscape, network developments and federal and state government policy:

- Continued growth of renewable energy generation, consumer energy resources (CER) and storage systems across Victoria – in both the transmission and distribution networks – is **making power flow bi-directional and altering traditional flow patterns**.
- **Investment remains strong**. Victoria's total installed large generation capacity[1] (at 30 August 2024) is 15.3 gigawatts (GW), consisting of 7.8 GW of large-scale renewable generation (wind, solar, storage and hydro) and 7.5 GW of large-scale conventional thermal generation (coal and gas).
- New large-scale renewable generation and storage projects totalling 360 megawatts (MW) have connected in Victoria over the past year, and another 1.2 GW is committed to connect[2].
- Over 22 GW of large-scale renewable generation and 15 GW of battery energy storage projects have submitted connection enquiries, of which 11 GW are currently going through either the optional pre-application process or the formal application stage.
- **The transmission network has a critical role in a robust power system** during the transition towards a future with fewer large synchronous generators, due to reduced availability or retirement. This includes Victoria's Yallourn W (scheduled to retire in 2028), Loy Yang A (2035) and Loy Yang B (2047).
- As household and business consumers continue to install their own distributed PV generation and storage systems, Victoria's **levels of minimum operational demand[3] continue to decline**, requiring additional market-based solutions (like coordinated storage and electric vehicle (EV) charging, scheduled loads such as pumping load, and demand response) to support system security. Victoria's minimum operational demand is expected to decline to zero by 2028 and reach -2.6 GW by 2033-34.
- The latest regional electricity demand forecasts indicate Victoria's summer peaking maximum demand continuing to steadily increase over the next decade, but at a lower rate than projected last year. On average, 1% year-on-year growth is projected in the 10% probability of exceedance (POE) forecast[4], leading to a peak of 11.4 GW in 2033-34.
- For later years in the planning horizon, the 10% POE maximum demand forecast demonstrates slower growth than last year's forecast, mainly due to the projected softening of EV demand and a less optimistic economic outlook.
- Although not assessed as part of this 2024 Annual Planning Review, over the past six months AVP has received enquiries for large data centre connections equating to approximately 4 GW of new load. There

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[1] See https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2024/register-of-large-generator/register_of_large_generator_connections-vic---august-2024.pdf.

[2] 'Committed' projects meet criteria relating to land, contracts, planning approvals, financing and construction.

[3] See at https://www.aemo.com.au/-/media/Files/Electricity/NEM/Planning_and_Forecasting/Demand-Forecasts/Operational-Consumption-definition.pdf

[4] POE is the statistical likelihood a forecast will be met or exceeded. A 10% POE forecast is expected on average to be exceeded only one year in 10 and is based on more extreme weather conditions than a 50% forecast, which is expected to be exceeded one year in two.

is considerable interest to supply these new large loads from existing terminal stations in the western metropolitan Melbourne area, and assessing the power system requirements for these new loads will be a key focus of the 2025 VAPR.

The Victorian DSN remained secure in 2023-24, as AEMO operated the system to manage the challenges of record low minimum demand, rapidly growing levels of variable renewable energy (VRE) generation, and non-credible incidents due to severe weather conditions. Notable network performance observations include:

- The annual peak Victorian operational demand in 2023-24 was 9,294 MW on 22 February 2024 (compared to the peak of 8,988 MW in 2022-23). Although marginally higher than the previous year, this peak remained low compared to the historical summer maximum demand of 10,576 MW in 2008-09, before Victorian consumers' substantial uptake of distributed PV.
- Victoria recorded its all-time lowest minimum operational demand of 1,594 MW on 31 December 2023. This was 601 MW lower than the previous record set last year, and the fifth consecutive year that the record has been broken. At the time of the record minimum demand, more than 3 GW of distributed PV supplied the majority of Victoria's underlying demand.
- A severe weather event caused significant damage to, and resulted in the failure of, six 500 kilovolts (kV) towers on 13 February 2024 in South West Victoria. Approximately 2,690 MW of generation was lost, and 1,000 MW of load was shaken off[5] in Victoria following the disturbance. In response, AEMO directed load shedding and emergency reserves were dispatched through Reliability and Emergency Reserve Trader (RERT) to maintain system security.
- Due to existing network constraints, curtailment of VRE generation was predominately observed in the Western Victoria and Murray River REZs during 2023-24.

Progress is being made on projects in AVP's Transmission Development Plan

One project has been delivered since the last VAPR:

- **The new 500/220 kV Cressy Terminal Station (TS)**, constructed as part of the connection of Golden Plains Wind Farm, was energised in July 2024. The Cressy TS ties in both 500 kV lines between Moorabool to Mortlake and Haunted Gully terminal stations, strengthening the existing 500 kV corridor in South West Victoria.

The following critically important projects are in the delivery stage and are expected to alleviate the constraints identified in this and previous VAPRs:

- **Western Renewables Link (WRL)** – this aims to unlock renewable energy resources, reduce network congestion, and improve utilisation of existing assets in Western Victoria. The scope includes a double circuit 500 kV overhead transmission line from Sydenham to near Bulgana with a 220 kV connection into the existing Bulgana 220 kV TS, and the project is expected to be completed in mid-2027.
- **VNI West** – this proposed new interconnector between Victoria and New South Wales consists of a high capacity 500 kV double circuit overhead transmission line to carry energy from the Murray River and Western

[5] Generalised disconnection of load in response to unusual network conditions during a disturbance, such as a deep voltage dip or phase angle jump.

Victoria REZs and increase export and import capability. Transmission Company Victoria (TCV) is currently refining the draft corridor through desktop and field environmental assessments, and holding discussions with landholders and communities, to arrive at a preferred easement, which is expected to be announced in October 2024. The project is expected to be energised in late 2028 and fully operational by the end of 2029.

- **RDP Stage 1 projects** – directed by the Victorian Government, this includes three system strength projects including turn-in of the Haunted Gully to Tarrone 500 kV line at Mortlake, and nine minor network augmentations. These projects support the connection of more low-cost renewable generation in regional Victoria and are progressing towards being finalised in late 2025.
- **EnergyConnect** – this interconnector between South Australia and New South Wales, with connection to Victoria at Red Cliffs, will have a transfer capacity of 800 MW. The project is aimed at reducing the cost of providing secure and reliable electricity across the NEM. Commissioning of Stage 1 and inter-network testing is expected in early 2025, enabling an initial transfer capacity of 150 MW.
- **Project Marinus** – this proposed underground and undersea electricity transmission project is comprised of two 750 MW high voltage direct current (HVDC) links to further connect Tasmania and Victoria. The project is proceeding with early works required to achieve a Final Investment Decision (FID) for Stage 1 by May 2025, enabling commissioning of the first cable in 2030.

The following RIT-Ts have progressed since the 2023 VAPR:

- **Metropolitan Melbourne voltage management** – addressing the previously identified network limitation on managing the voltages in metropolitan area during high and low demand times. AVP published the Project Assessment Draft Report (PADR) in July 2024, which reassessed the identified need presented in the Project Specification Consultation Report (PSCR) and presented the proposed preferred option.
- **Victorian system strength requirements** – addressing a limitation identified in the 2022 VAPR and system strength requirements identified through AEMO's 2022 System Strength Report. AVP is expecting to publish the PADR in April 2025, proposing a preferred options portfolio that will consist of a range of system strength services agreements with new and existing synchronous unit proponents and grid-forming battery energy storage system (BESS) proponents.

Following prefeasibility studies completed for the limitations identified in the 2023 VAPR for eastern and western metropolitan Melbourne, AVP commenced two new RIT-Ts:

- **Eastern Victoria Grid Reinforcement** – addressing priority limitations identified in the 2023 VAPR in Victoria's eastern 220 kV ring, including Rowville A1 500/220 kV transformer overloads. AVP is currently undertaking scoping studies to assess credible options and expects to publish the Project Specification Consultation Report (PSCR) in Q4 2024, outlining credible network options and technical characteristics required from non-network options to meet the identified need, being to support the forecast demand growth in the eastern metropolitan area.
- **Western Metropolitan Reinforcement** – addressing priority limitations identified in the 2023 VAPR for the 220 kV corridor between Moorabool and Keilor. AVP is expecting to publish the PSCR by Q1 2025, quantifying the identified need, outlining the credible options to be considered in the RIT-T, and summarising the technical characteristics required of a non-network option to meet the identified need.

Other projects that are currently undergoing scoping and development include:

- **Latrobe Valley reconfiguration** – since the 2023 VAPR, AVP has begun working with relevant asset owners to develop the scope of works and ensure works will be completed to transition to modified parallel operating mode when Yallourn W Power Station (YWPS) retires.
- **Offshore wind transmission project** – AVP is working closely with VicGrid in developing the declared shared transmission infrastructure from a hub on the Gippsland coast to the 500 kV Loy Yang Power Station (LYPS) switchyard to facilitate the Victorian Government's initial 2 GW target for offshore wind generation by 2032. Community engagement has commenced, and a transmission line study area was released in 2024.

Figure 1 and **Figure 2** present AVP's Transmission Development Plan for Victoria, illustrating respectively the plan infrastructure projects that have been delivered in the past 12 months, and those that are currently in progress.

Figure 1 Newly completed Transmission Development Plan projects for Victoria

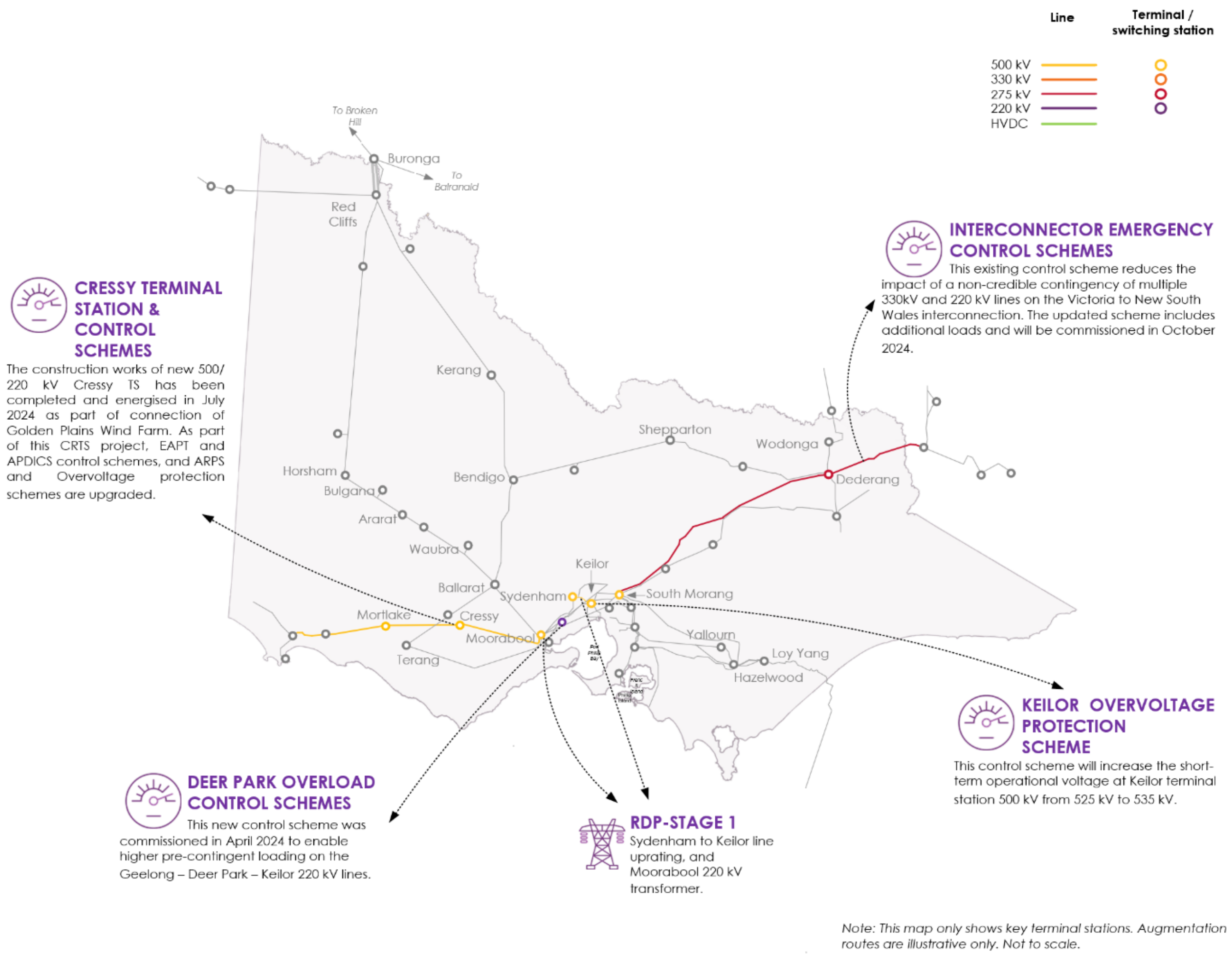
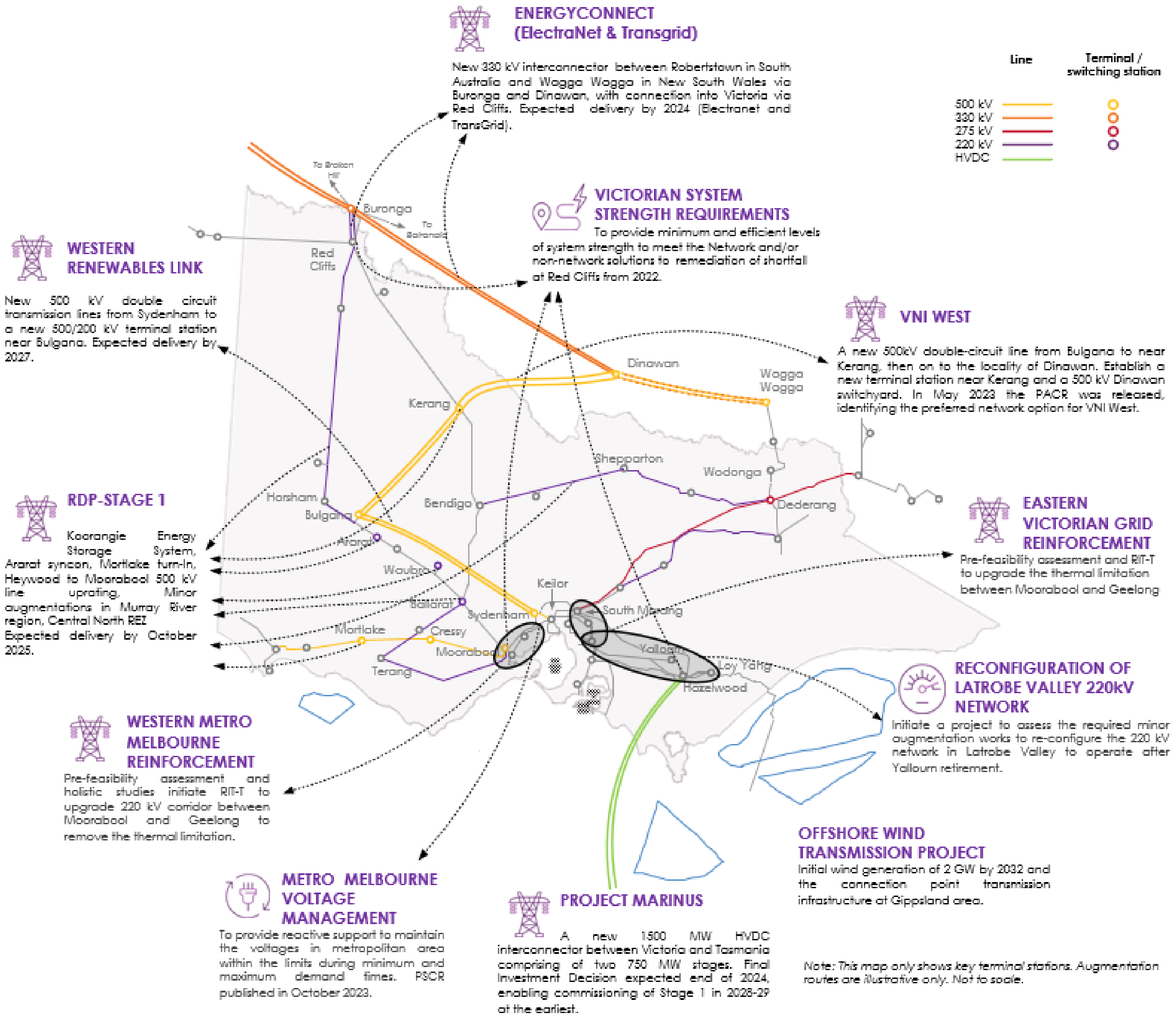


Figure 2 In progress Transmission Development Plan projects for Victoria



The future outlook of the 2024 VAPR reiterates the need to progress with regulatory tests to address previously identified network limitations

AVP's annual planning review for Victoria assesses the current and forecast supply, demand, and operational challenges to identify potential new network limitations and proposes solutions that can help reduce overall costs to Victorian consumers by unlocking lower-cost generation supply, increasing power system resilience, and improving the efficiency of resource sharing between Victoria and its neighbouring regions in the NEM.

The key messages from the 2024 VAPR are:

- This assessment, like those published in the last two VAPRs, consistently demonstrates emerging network limitations and the **urgency of delivering previously identified augmentation projects**.

- **The latest assessment is consistent with the 2023 VAPR** – the projection of network limitations and their impact on the performance of the DSN is largely consistent with the 2023 assessment. AVP has classified two new priority limitations, which were both identified as monitored limitations (low impact) in previous VAPRs:
  - **Eildon – Thomastown 220 kV line thermal limitation** – this previously identified limitation was reclassified from a monitored to a priority limitation[6] due to the increased demand forecast in Melbourne's eastern metropolitan area, specifically supplied at Ringwood, Templestowe and Thomastown Terminal Stations. AVP expects the Eastern Victorian Grid Reinforcement project would alleviate this limitation.
  - **Red Cliffs – Wemen – Kerang 220 kV line thermal limitation** – this previously identified limitation was reclassified from a monitored to a priority limitation[6] due to the latest demand forecast. The primary driver of this limitation is the substitution of power flow following retirement of Yallourn, by increased flow from New South Wales into Victoria at Red Cliffs during periods of high demand. AVP will begin pre-feasibility studies to assess the limitation and identify credible options to address it.
- It is critically important to progress the transmission projects in Victoria's network development plan, to ensure supply reliability and deliver consumer benefits – the future outlook of the 2024 VAPR highlights the importance of moving forward with the already commenced regulatory tests and approvals of the planned projects initiated by the previous VAPRs to deliver consumer benefits in a timely manner and maintain the reliability of electricity supply in Victoria.
- Proactive engagement is needed between AVP and Victoria's Declared Transmission System Operators (DTSOs) and distribution businesses (DBs) to identify the optimal solutions for asset replacement projects and manage operational challenges:
  - AVP continues timely and effective joint planning with AusNet Services to identify the optimal solutions to key replacement projects including (but not limited to):
    - South Morang Terminal Station 500/330 kV and 330/220 kV transformers.
    - Keilor 500/220 kV transformers.
    - Moorabool 500/220 kV transformer
  - AVP continues to work with other DTSOs and DBs to identify credible and cost-effective solutions to the emerging challenges caused by the increased fault levels across the DSN, due to the growing generation portfolio, and managing system security at times of low demand.

[6] See Section 4.1.1 for an overview of limitation classifications.

Contents

Tables

Figures

1 Introduction

This section outlines the purpose and summarises the content of the 2024 *Victorian Annual Planning Report* (VAPR).

1.1 Purpose and scope of the 2024 VAPR

The 2024 VAPR provides useful information to stakeholders about the Victorian electricity transmission Declared Shared Network (DSN). It assesses the adequacy of the DSN over a 10-year planning horizon to ensure the DSN meets network performance requirements to supply electricity to Victorian consumers in a secure and reliable manner.

The VAPR presents the Transmission Development Plan for Victoria while identifying network limitations for further investigation.

To assess the adequacy of the DSN over the 10-year planning horizon, the VAPR takes into account:

- The most recent demand forecasts (2023 AEMO Connection Point demand forecast and 2024 *Electricity Statement of Opportunities* (ESOO) regional demand forecasts[7]).
- Generation plant and retirement information (using the July 2024 update on AEMO's Generation Information web page[8], Register of Large Generators Victoria[9], and AVP Internal connections project information.
- Committed, anticipated and future *Integrated System Plan* (ISP) projects (from AEMO's Transmission Augmentation Information page[10]) and network/non-network projects initiated by VicGrid.
- Committed distribution augmentations identified in the 2023 Transmission Connection Planning Report[11] prepared by the Victorian distribution network service providers (DNSPs).
- Committed asset retirements and deratings as per the 2024 Declared Transmission System Operators' (DSTOs') Asset Renewal Plans.

With this assessment, AEMO Victorian Planning (AVP) updates its Transmission Development Plan for Victoria, which outlines the strategy for Victoria to provide a transmission system which best meets the needs of the DSN's stakeholders.

This plan builds on the national plan developed through AEMO's ISP. The VAPR provides insights relating to the DSN's performance, supply and demand changes and forecasts for the next decade, emerging network needs, and the AVP's Transmission Development Plan for the DSN, with a particular focus on developments most likely to

[7] At https://aemo.com.au/energy-systems/electricity/national-electricity-market-nem/nem-forecasting-and-planning/forecasting-and-planning-data/electricity-forecasting-data-portal.

[8] At https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/nem-forecasting-and-planning/forecasting-and-planning-data/generation-information.

[9] At https://aemo.com.au/energy-systems/electricity/national-electricity-market-nem/participate-in-the-market/network-connections/register-of-large-generators---victoria.

[10] At https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/nem-forecasting-and-planning/forecasting-and-planning-data/transmission-augmentation-information.

[11] At https://dapr.ausnetservices.com.au/ausnet_data/2023%20TCPR.pdf.

deliver positive net economic benefits to energy consumers or where corrective action is required to keep the DSN reliable and secure.

The Annual Planning Review undertaken by AVP and presented in this report has considered the policy initiatives and directives of the Federal Government and Victorian Government (see Section 2.4) in identifying network limitations for the next 10 years and proposing solutions to those limitations in the Transmission Development Plan for Victoria.

1.2 Roles and responsibilities

1.2.1 AEMO Victorian Planning (AVP)

AVP currently holds the role of transmission network service provider (TNSP) planner in the jurisdiction of Victoria. While there are multiple Declared Transmission System Operators (DTSOs) in Victoria, AVP is responsible for planning and directing augmentation of the DSN in Victoria[12].

The National Electricity Rules (NER) require all jurisdictional planning bodies of the National Electricity Market (NEM) to undertake an Annual Planning Review followed by publishing a Transmission Annual Planning Report (TAPR) by 31 October each year, as outlined in NER 5.12.1 and 5.12.2 respectively.

Other obligations and responsibilities that AVP holds as the Jurisdictional Planning Body for Victoria include:

- Initiating network investment for cost-effective solutions for consumers, including conducting regulatory investment tests for transmission (RIT-Ts) on potential transmission network and non-network projects.
- Undertaking joint planning with the DTSOs and DNSPs, AEMO National Planning and neighbouring TNSPs.

1.2.2 VicGrid

VicGrid is a body within Victoria's Department of Energy, Environment and Climate Action (DEECA) established to coordinate the overarching planning and development of Victorian renewable energy zones (REZs).

In May 2024, an amendment to the *National Electricity (Victoria) Act 2005* (NEVA) legislated the establishment of VicGrid as a statutory authority with the following responsibilities[13]:

- Coordinating the planning and development of REZ infrastructure.
- Investing in projects to strengthen and modernise Victoria's energy grid.
- Changing the planning and development framework of the electricity transmission infrastructure in Victoria to ensure it benefits all Victorians, through the Victorian Transmission Investment Framework (VTIF – see below).
- Coordinating the delivery of the transmission required to connect new offshore wind resources to the grid.
- Working with AVP to deliver major infrastructure upgrades.
- Providing information to communities.

[12] See https://aemo.com.au/energy-systems/electricity/national-electricity-market-nem/nem-forecasting-and-planning/victorian-planning/victorian-transmission-network-service-provider-role.

[13] See https://www.energy.vic.gov.au/renewable-energy/vicgrid.

Victorian Transmission Investment Framework (VTIF)[14]

In March 2024, the Victorian Government finalised legislation introducing the VTIF, a new regulatory framework with a comprehensive set of reforms to support state's energy transition. VTIF is an integrated approach for planning and delivering electricity transmission infrastructure on a coordinated basis that will support development of REZs across Victoria.

Victorian Transmission Plan (VTP)

Under the new VTIF framework, VicGrid will develop the VTP as a 25-year comprehensive strategic plan for Victorian transmission and REZ development. VicGrid published the 2024 VTP Guidelines in September 2024, and the first VTP is expected to be published in July 2025, addressing the first 15 years of the time horizon.

1.3 Structure of the 2024 VAPR

The 2024 VAPR consists of three main sections and a number of supporting documents as listed in Section 1.5:

- **Section 2 – Drivers of the energy transition in Victoria** outlines the overall context for this review of the Victorian DSN, including the changing nature of supply and demand, the need for resilience in the power system, and policy and regulatory updates.
- **Section 3 – Victoria's Transmission Network Development Plan** provides an update on network development activities and regulatory investment tests that have progressed since the 2023 VAPR.
- **Section 4 – Future outlook of the Victorian DSN** provides a forecast of network limitations for the planning horizon and proposes potential solutions. This section also contains information about ongoing activities for system security planning, control schemes required to manage DSN performance, and joint planning activities with other network service providers (NSPs).
- **Appendix A1** summarises AVP's approach to the network limitation review.
- **Appendix A2** provides details of DSN limitations, as an outcome of this review.

1.4 AVP is seeking feedback on the value of information in this report

AVP welcomes stakeholder submissions on the usefulness of the 2024 VAPR, and on potential improvements or additional information sources that would be valuable to stakeholders in future VAPR Reports. This may include feedback on:

- The future inclusion of fault level maps.
- Existing power quality (voltage distortion and flicker) levels in comparison with the Planning Limits.
- Locational information about the potential large data centre loads.

Send your written submissions to VIC.Planning@aemo.com.au by 31 December 2024.

[14] See https://engage.vic.gov.au/download/document/31853.

1.5 Supporting material

Table 1 lists a suite of electronic resources published by AEMO to support the content in this report. Unless otherwise indicated, these resources are published alongside the VAPR on AEMO's website[15].

Table 1 2024 VAPR supporting resources

Resource	Description
Victorian Network Performance and Insights Report (VNPIR)	Formerly a chapter of the VAPR, this report provides an overview and key insights of the performance of the DSN during financial year 2023-24 and reviews the capabilities and challenges of the present-day network to inform the VAPR.
Historical DSN rating and loading workbook	Ratings and loadings for the 2023-24 maximum demand and high export periods presented in Section 3 and Appendix A2.
AusNet Services 2024 asset renewal plan	AusNet Services' transmission asset renewal process provides a list of planned asset renewal projects, including asset retirements and de-ratings for the next 10-year period, including changes since last year and the options considered.
Asset related datasets	• Transmission connection point data for each transmission terminal station where primary station assets are associated with an actual or forecast emerging network limitation. • Transmission line segment data for each transmission line between terminal stations that are associated with a historical or emerging line capacity limitation. • Aggregated generation connection data for each connection application or new (completed over the last 12 months) connection agreement at terminal stations or areas where the connections could affect existing or emerging network limitations.
2023 Victorian Connections Point Demand Forecast	AEMO's internal maximum and minimum demand forecasts for the Victorian connection points.
System security reports	AEMO's system strength, inertia and network support and control ancillary services (NSCAS) assessments, collectively known as the System Security Reports under NER 5.20. At https://aemo.com.au/energy-systems/electricity/national-electricity-market-nem/nem-forecasting-and-planning/system-security-planning.
Metropolitan Melbourne Voltage Management RIT-T Project Assessment Draft Report (PADR)	The second publication in the Metropolitan Melbourne Voltage Management RIT-T process, at https://aemo.com.au/-/media/files/initiatives/metropolitan-melbourne-voltage-management-rit/melbourne-metropolitan-voltage-management-project-assessment-draft-report.pdf.
Victorian System Strength Requirement RIT-T Project Specification Consultation Report (PSCR)	Victorian system strength requirement regulatory investment test for transmission (RIT-T), at https://aemo.com.au/-/media/files/initiatives/victorian-system-strength-requirement-rit/victorian-system-strength---project-specification-consultation-report_final.pdf.
General Power System Risk Review (GPSRR)	An integrated, periodic review of major power system frequency risks associated with non-credible contingency events in the NEM (previously the Power System Frequency Risk Review). At https://www.aemo.com.au/energy-systems/electricity/national-electricity-market-nem/system-operations/general-power-system-risk-review.
Enhanced Locational Information Report (ELI)	Provides a consolidated set of locational information to inform decisions about where to locate projects in the NEM. At https://aemo.com.au/energy-systems/electricity/national-electricity-market-nem/nem-forecasting-and-planning/forecasting-and-planning-data/enhanced-locational-information.

[15] At https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/nem-forecasting-and-planning/victorian-planning/victorian-annual-planning-report.

2 Drivers of the energy transition in Victoria

This section outlines information about the changing energy landscape in Victoria that is relevant for transmission planning. This includes a summary of key changes in energy consumption and supply patterns and government policies, updated generation and storage projects since the publication of the 2023 VAPR, and insights from the latest demand and energy consumption forecasts for Victoria.

Key insights

- Victoria's rapid energy transition is being driven by large-scale renewable energy generation, so far mostly developed in the west of the state, and the strong uptake of distributed generation by consumers across Victoria.
- Victoria recorded its all-time lowest minimum operational demand of 1,564 megawatts (MW) on 31 December 2023. This was 631 MW lower than the previous record set last financial year. Minimum demand has occurred during the daytime due to high output from distributed photovoltaic (PV) generation relative to underlying demand.
- Government policies and incentive schemes, increasing industry commitment towards large-scale investments in renewable energy generation, fast-growing consumer investment in distributed renewable resources, and the application of new technologies, are reshaping how Victorians use the transmission network.
- Investment remains strong, particularly in BESS in the Southwest, Northwest and Northern regions of Victoria. A total of 1.2 GW of BESS projects reached the committed stage since the 2023 VAPR.
- New generation/storage commitments since the 2023 VAPR total 1.2 GW of solar and wind generation, while another 360 MW of wind and solar generation connected to the DSN.
- The maximum installed large generation capacity, together with committed generation, in the Victorian DSN as of July 2024, is 15.3 GW, consisting of:
- Renewable generation capacity of 7.8 GW:
    - 7.1 GW of large-scale wind, solar generation, and battery storage.
    - 0.7 GW of hydro generation.
- Thermal generation capacity of 7.5 GW:
    - 5.1 GW of coal generation, of which 1.6 GW is announced to be retired in next 10 years.
    - 2.4 GW of gas generation.
- Maximum demand is forecast to continue increasing steadily at a 1% yearly growth rate, reaching 11.4 GW at the end of the 10-year planning period. Compared to very strong uptake in the 2023 forecast, EV demand projections are lower, reducing forecast maximum demand in the long term, while marginal uplift can be seen in the short term due to some committed data centre loads. Data centre loads equating to

approximately 4 GW have submitted connection enquiries, but these are not included in the 2024 ESOO demand forecasts.

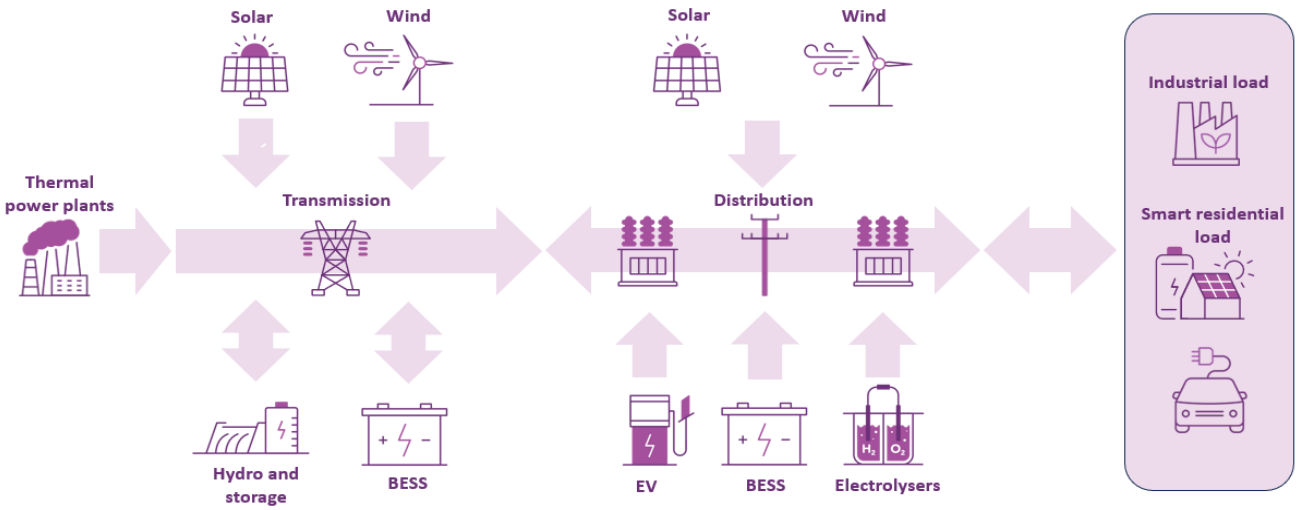
- Minimum demand is forecast to decline rapidly, reaching 0 GW by 2029 and -2.6 GW by the end of the planning horizon.

2.1 Evolving energy consumption and supply

Traditional energy consumption has changed, with the introduction of non-conventional and smarter electricity usage patterns throughout the day in Australian households and businesses. Consumer choices and behavioral changes are driving increasing energy efficiency for cooking, heating, and cooling, as well as new ways to manage energy through CER – domestic and small-scale energy storage systems, electric vehicles (EVs), and changes in the operating cycles of appliances such as hot water, air-conditioning and heat pumps.

As **Figure 3**shows, generation supply has become more distributed, in a change from traditional centralised generation. This means generation is diversified on both supply and user sides and energy increasingly flows in both directions – towards and from consumers.

Figure 3 Bi-directional flow paths in modern-day power systems



The future power system will be coordinated across multiple elements of the changes in energy supply and consumption patterns. The key changes observed in the transition towards a modern power system, including in Victoria and across the Australia's energy markets, are:

- Continued growth in CER, including distributed photovoltaic (PV) generation, BESS and electric vehicles (EVs).
- Virtual power plants (VPPs) are starting to aggregate CER assets into larger systems, trading energy between them and the grid, and maximising the system benefits that these resources can provide[16].

[16] See at https://aemo.com.au/en/energy-systems/major-publications/integrated-system-plan-isp/2024-integrated-system-plan-isp

- Growing operational challenges to maintain system security and meet consumer requirements in the broader power system due to low and negative demand conditions, driven by the combined effect of high levels of distributed PV relative to underlying demand. In Victoria, an increasing number of distributed generators (including distributed PV) connecting at the distribution level has led to reverse power flows at several terminal stations, which were primarily established to supply customer loads. In 2023-24, the total number of hours of reverse power flows held relatively steady compared to 2022-23. More co-ordinated approaches with DNSPs will be required to manage the operational challenges caused by the reverse power flows.
- Victoria recording its all-time lowest minimum operational demand of 1,564 MW on 31 December 2023[17]. This was 631 MW lower than the previous record set last financial year. Minimum demand is now occurring during the daytime because of the effect of distributed PV generation. At the time of minimum demand on 31 December 2023, 3 gigawatts (GW) of distributed PV generation was observed.
- Increased potential for large inverter-based block loads like data centres and hydrogen electrolysers connecting to the network.

Victoria's transition from fossil fuels to clean energy sources, to deliver low cost and reliable energy to households and businesses via a secure power system, is well underway as consumers, investors and governments continue to develop renewable generation and storage.

The main load centres in Victoria are in metropolitan Melbourne and the Geelong area, where the bulk of the state's energy is consumed by households or businesses.

Changes happening in the energy landscape mean careful and proactive coordination is required to plan and operate the power system. Due to the increased and growing proportion of CER generating energy in the distribution network, the power flow has become bi-directional at terminal stations which were historically established as bulk supply points into the distribution network where most of the energy has been consumed. These changes are creating additional operational challenges as well as the need for proactive planning measures.

2.2 Growth in renewable energy sources allowing orderly exit of coal power plants

Historically, Victoria's power generation was predominantly based on brown coal power plants in the Latrobe Valley, and some gas-powered generation units used to firm up demand during peaking times. Hazelwood Power Station retired in 2017, and the remaining coal fleet, which is aging, is expected to retire within two decades.

The services provided by these large rotating machines – such as inertia and frequency control, and supply or absorption ability of reactive power – must be fulfilled by other sources and technologies as potential future market services[18].

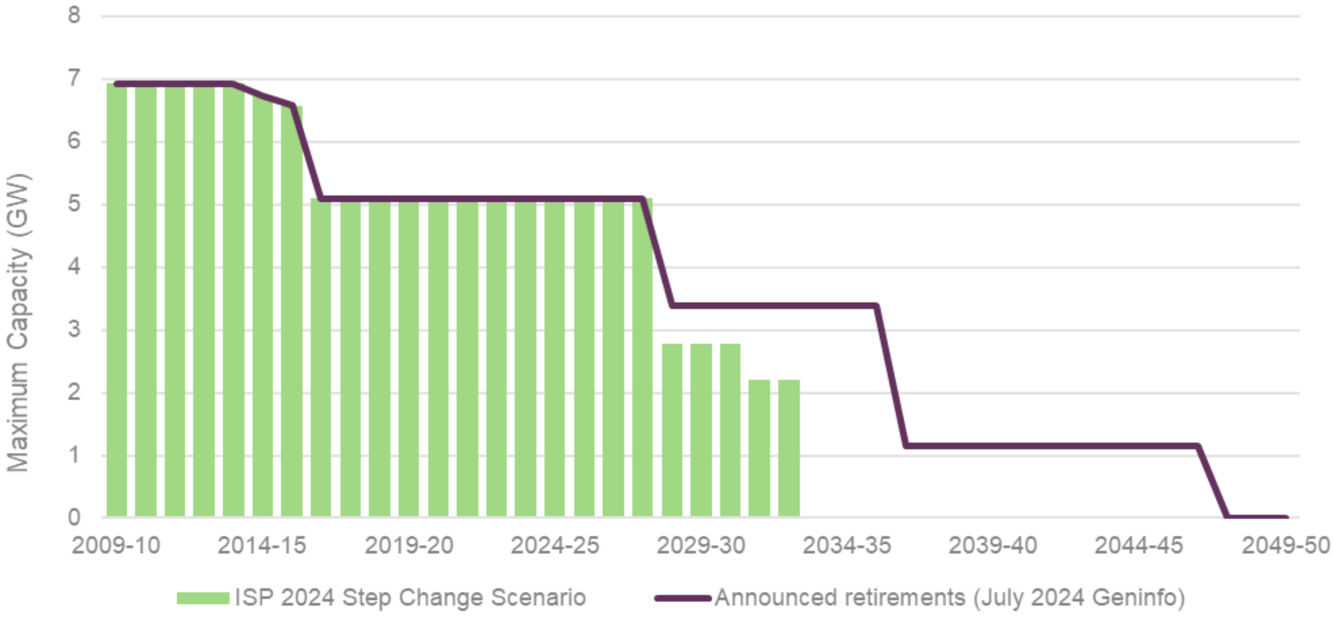
[17] See the *Victorian Network Performance and Insights Report*, at https://aemo.com.au/energy-systems/electricity/national-electricity-market-nem/nem-forecasting-and-planning/victorian-planning/victorian-annual-planning-report.

[18] See https://aemo.com.au/-/media/files/electricity/nem/security_and_reliability/system-strength-requirements/2023-inertia-report.pdf.

Figure 4 illustrates the existing available coal generation capacity in Victoria, its expected decrease over the next two decades due to announced coal plant retirements, and the advanced reduction in coal capacity forecast in the 2024 ISP *Step Change* scenario. In this scenario, all Victoria's coal fleet is forecast to retire by 2033-34.

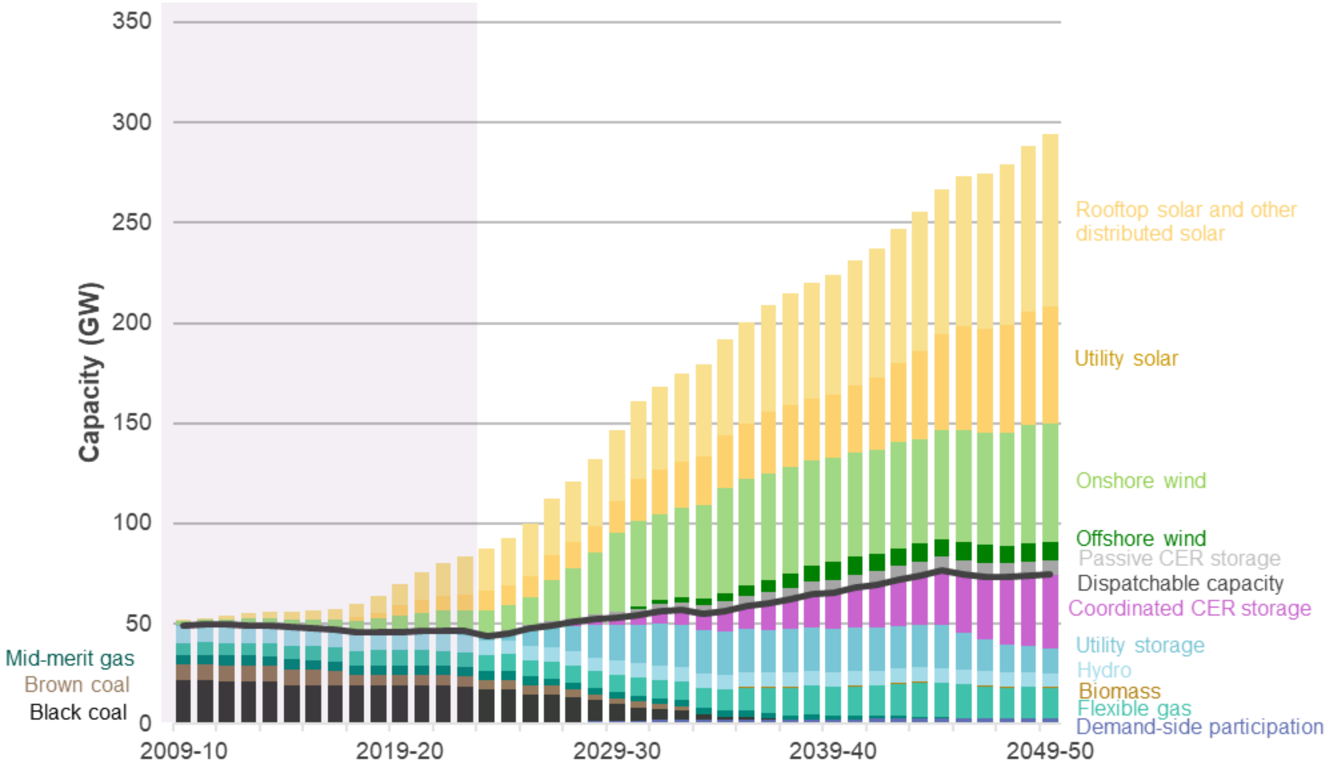
The 2024 ISP identifies the optimal development path for reliable and affordable energy – renewable energy connected by transmission and distribution, firmed with storage and backed up by gas-fired generation, will be the lowest-cost way to supply electricity to homes and businesses as Australia transitions to a net zero economy. **Figure 5** shows expected generation capacity across the NEM to 2050 in the optimal development path of the 2024 ISP *Step Change* scenario. It highlights that, as coal generation retires, supply adequacy needs to be balanced with growth in renewable generation, with about 6 GW of additional generation capacity needing to be added to the NEM every year.

Figure 4 Victorian coal power generation retirement (GW)



Source: AEMO, 2023 *Inputs, Assumptions and Scenarios Report*. Geninfo is AEMO's Generation Information webpage, at https://www.aemo.com.au/energy-systems/electricity/national-electricity-market-nem/nem-forecasting-and-planning/forecasting-and-planning-data/generation-information.

Figure 5 Generation capacity in the NEM, 20924 ISP *Step Change* scenario, 2009-10 to 2049-50 (GW)



Notes: Flexible gas includes gas-powered generation and potential hydrogen capacity. CER storage means consumer energy resources such as batteries and electric vehicles. Projections for rooftop solar and other distributed solar and CER storage were based on unit costs, consumer trends and assumptions about payments received to participate in the electricity market.

2.3 The critical role of the transmission network in a robust power system

A key element of a robust power system is its ability to maintain system security and reliability during extreme operating conditions driven by factors such as high or low demand levels, lack of system strength and/or inertia, and extreme climate events.

Reduced availability (due to displacement or orderly retirement) of conventional generation units online can lead to shortfalls in system strength and inertia, which are critical characteristics enabling the power system to recover from sudden disturbances and maintain stability.

A severe storm activity on 13 February 2024 caused significant damage to, and resulted in the failure of, six 500 kilovolts (kV) towers in South West Victora. Approximately 2,690 MW of generation was lost, and 1,000 MW of load was shaken off[19] in Victoria following the event to maintain the security of the power system.

Maintaining the resilience of the DSN through these challenges is critical. The future power system will be more complex with the continuing growth of renewable inverter-based resources (IBR) on the supply side as well as large inverter-based loads, and ongoing rapid uptake in renewable energy-based sources diversified across both transmission and distribution networks. As such, planning the power system is essential to ensure it continues to operate reliably to meet consumer needs.

[19] Disconnection of load in response to unusual network conditions during a disturbance, such as a deep voltage dip or phase angle jump.

The transmission network continues to play a critical role in maintaining a resilient power system, as the backbone or primary corridor of the power system to transfer the energy sourced from renewable generation across Victoria and neighboring regions into Victoria's large load centres.

The 2024 ISP's optimal development path identifies over 10,000 km of transmission projects by 2050 across the NEM, under the *Step Change* scenario, including major augmentation projects that have been identified as committed/anticipated or actionable for Victoria to enable the optimal development path. The development of these projects is critical to ensure the resilience of the overall power system in Victoria.

2.4 Government policies and initiatives supporting the energy transition

The Victorian Government has made a range of commitments and policy announcements to enable the energy transition and support the connection of renewable generation. These commitments and policies have significant impact on the drivers for, and economics of, investment opportunities in the Victorian electricity network. Major government policies or initiatives that are relevant for the 2024 VAPR are:

- Victorian Transmission Investment Framework (VTIF)[20] and Victorian Transmission Plan (VTP) – see Section 1.2.2 for details.
- Victorian transmission planning objectives – with the new functions of VicGrid, a new Victorian transmission planning objective, as set out in amendments to the National Electricity (Victoria) Act 2005 (NEVA), passed in May 202421. The new objective incorporates environmental objectives and the state's needs in response to the energy transition and will guide how transmission planning and investment decisions are made in Victoria.
- REZ Development Plan (RDP) – as outlined in the RDP Directions Paper[22], AEMO worked with the Victorian Government to develop the RDP Stage 1 projects to provide short- to medium-term solutions to strengthen the existing network and accelerate REZs. In 2022, the Victorian Government issued the Third RDP Stage 1 NEVA Order directing AEMO to enter into contracts with the declared transmission system operator for the network augmentations identified in RDP Stage 1[23]. For progress of the delivery of the projects since 2023 VAPR, see Section 3.1.2.
- Offshore Wind Targets – the Victorian Offshore Wind Policy Directions Paper identified the waters off the Victorian coast as "a world-class offshore wind resource, with at least a 13 GW opportunity in initial tranches near Gippsland and Portland"[24]. The Federal Government declared the Southern Ocean REZ in March 2024 with a potential of 2.9 GW in addition to the previously declared Gippsland REZ[25].
- The Victorian Government announced it will support the establishment and growth of this emerging industry by committing to a 2032 offshore wind target for Victoria of at least 2 GW, and is aiming for the first power by

[20] See https://engage.vic.gov.au/download/document/31853.

[21] See https://www.legislation.vic.gov.au/bills/national-electricity-victoria-amendment-vicgrid-bill-2024.

[22] At https://www.energy.vic.gov.au/__data/assets/pdf_file/0028/580618/Victorian-Renewable-energy-zones-development-plan-directions-paper.pdf.

[23] Victoria Government Gazette No. S547, 14 October 2022, at http://www.gazette.vic.gov.au/gazette/Gazettes2022/GG2022S547.pdf.

[24] See https://www.energy.vic.gov.au/renewable-energy/offshore-wind-energy.

[25] See https://www.dcceew.gov.au/energy/renewable/offshore-wind/areas/southern-ocean-region.

2028, after a competitive process. See Section 3.1.2 for more details about planned offshore wind development activities.

- Victorian energy storage targets[26] – announced in September 2022, these targets aim to connect at least 2.6 GW by 2030 and at least 6.3 GW by 2035 of both short- and long-duration energy storage systems. The inclusion of both short- and long-duration systems will allow energy to be moved around during the day and to be supplied through longer duration imbalances.
- Victorian Renewable Energy Target Auction #2 (VRET2)[27] – six projects were announced by the Victorian Government in October 2022 to bring online 623 megawatts (MW) of new renewable energy generation capacity and up to 365 MW/600 megawatt hours (MWh) of new energy storage. VRET2 will help meet Victoria's legislated renewable energy targets of 40% by 2025 and 50% by 2030 (see below). Much of the proposed variable renewable energy (VRE) is expected to be built in the Victorian REZs, which seek to coordinate network and renewable generation investment.
- Victorian Renewable Energy Target – in March 2024, the Victorian Government legislated the new Renewable Energy Targets for Victoria as 40% by 2025, 65% by 2030 (previously 50%) and 95% by 2035 (new)[28]. These targets include the offshore wind energy generation targets described earlier.
- Zero Emission Vehicle (ZEV) Road Map[29] – the transport sector is one of the largest and growing sources of greenhouse gas emissions, and accounts for 25% of Victoria's total carbon emissions. In May 2024, the Victorian Government introduced the Zero Emission Vehicle Road Map aiming for half of all light vehicle sales in Victoria to be zero emissions vehicles. The road map is supported by a range of policies and programs including rollout of EV charging infrastructure across regional Victoria and support for EV fleets.
- State Electricity Commission (SEC)[30] – SEC was re-instated in October 2023 by the Victorian Government with an aim to invest in renewable energy and storage markets. SEC's strategic plan includes investing to accelerate the energy transition, supporting the switch to all-electric-households and building a renewable energy workforce.
- Victorian Emission Reduction Target[31] – in May 2023, the Victorian Government confirmed the new emission reduction target for 2035. The new targets to reduce the state's emission are 75-80% by 2035 and net zero emission by 2045.
- Energy innovation fund[32] – in addition to the three offshore wind projects that secured funding under Round 1 (completed in March 2022) to support feasibility and pre-construction activities, four other projects secured funding under Round 2, including Terang 100 MW/200 MWh grid-forming energy storage and the Yarra Valley Water Hydrogen project.

[26] See https://www.energy.vic.gov.au/renewable-energy/victorian-renewable-energy-and-storage-targets#heading-1.

[27] See https://www.energy.vic.gov.au/renewable-energy/victorian-renewable-energy-and-storage-targets/victorian-renewable-energy-target-auction-vret2.

[28] See https://www.energy.vic.gov.au/renewable-energy/victorian-renewable-energy-and-storage-targets.

[29] See https://www.energy.vic.gov.au/renewable-energy/zero-emission-vehicles#heading-3.

[30] See https://en.wikipedia.org/wiki/State_Electricity_Commission_of_Victoria.

[31] See https://www.climatechange.vic.gov.au/climate-action-targets.

[32] See https://www.energy.vic.gov.au/grants/energy-innovation-fund.

- **Solar Homes Program**[33] – Solar Victoria released its Notice to Market for 2023-24, introducing new requirements to support stability of the energy grid, while helping meet the growing demand for all-electric homes and businesses, by requiring system installations to comply with dynamic export requirements to meet future energy needs[34].
- **Victoria's Gas Substitution Roadmap**[35] – this roadmap was introduced in 2022, aiming to empower households and businesses in Victoria to switch to sustainable and cost-effective alternatives from fossil gas. From 1 January 2024, the phase-out of new gas connections will apply to new dwellings, apartment buildings and residential subdivisions that require a planning permit. An update to the roadmap was published in May 2024, highlighting the progress made so far.
- **Capacity Investment Scheme (CIS)**[36] – the CIS provides a national framework to encourage new investment in renewable capacity, such as wind and solar, as well as clean dispatchable capacity, such as battery storage. On 23 November 2023, the Australian Government announced an expansion of the CIS to target a total of 32 GW of new capacity nationally, which includes tender for dispatchable capacity in Victoria.

2.5 Supply changes – continuing investments in grid-scale renewable generation and storage

Enabling the energy transition in a timely manner will require fast-tracking new connections projects that benefit consumers and communities to unlock renewable potential, and solutions to alleviate transmission constraints, to enable renewable generation while maintaining system security and reliability.

Victoria's transition is driven by investment in large-scale renewable energy generation, primarily concentrated in the state's northern, western, and south-western regions. Government policies and initiatives (see Section 2.4), such as VRET2, have enabled a total of approximately 1.4 GW of new renewable energy generation capacity and up to 365 MW/600 MWh of new energy storage that is planned to be online in Victoria by 2025[37].

AVP defines projects by the following definitions:

- **Proposed** – projects that proponents have proposed, that have not yet met commitment criteria.
- **Committed** – projects where Connection Agreements have been executed and the project is unconditional[38].
- **Commissioned** – projects where all Hold Point testing[39] has been completed and AEMO has approved the generator for output at full maximum capacity.

[33] See https://www.solar.vic.gov.au/.

[34] See https://www.energy.vic.gov.au/renewable-energy/solar-energy/victorias-emergency-backstop-mechanism-for-solar.

[35] See https://www.energy.vic.gov.au/renewable-energy/victorias-gas-substitution-roadmap.

[36] See https://www.dcceew.gov.au/energy/renewable/capacity-investment-scheme

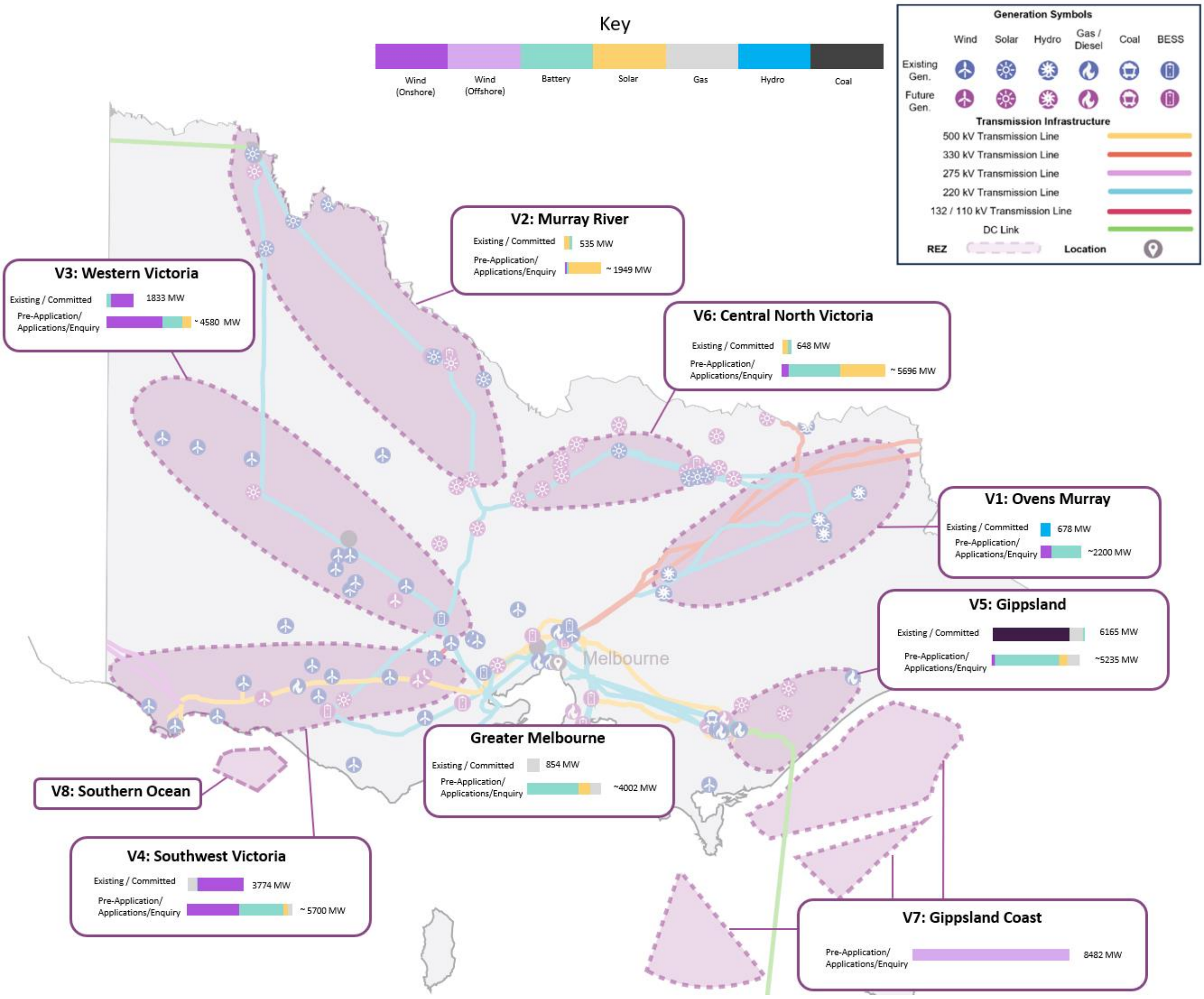
[37] See https://www.energy.vic.gov.au/renewable-energy/victorian-renewable-energy-and-storage-targets/victorian-renewable-energy-target-auction-vret2.

[38] Projects are considered unconditional when all the condition precedents have been met.

[39] When commissioning new or upgraded *plant* for the first time or making a change to *control system* settings or mode of operation Hold Points are generally required, whereby the *generating system's* overall output is constrained to a pre-defined megawatt (MW) level, which increases following successful completion of each level.

Figure 6 shows the high investment interest for renewable generation and storage in Victoria across existing projects and the pipeline for connection in the outlook period.

Figure 6 Summary of existing generation capacity and connections pipeline in Victoria



The 2024 VAPR assessment considered the installed capacity of existing and projected generation/storage connections on the DSN exceeding 30 MW[40]. Other generation/storage projects connected to the distribution network, including consumers' distributed PV and embedded generation, were not included in the assessment.

The total large generator installed capacity plus committed generation and storage projects in Victoria as of 30 September 2024 is 15.3 GW[41]:

- Renewable generation capacity is 7.8 GW:

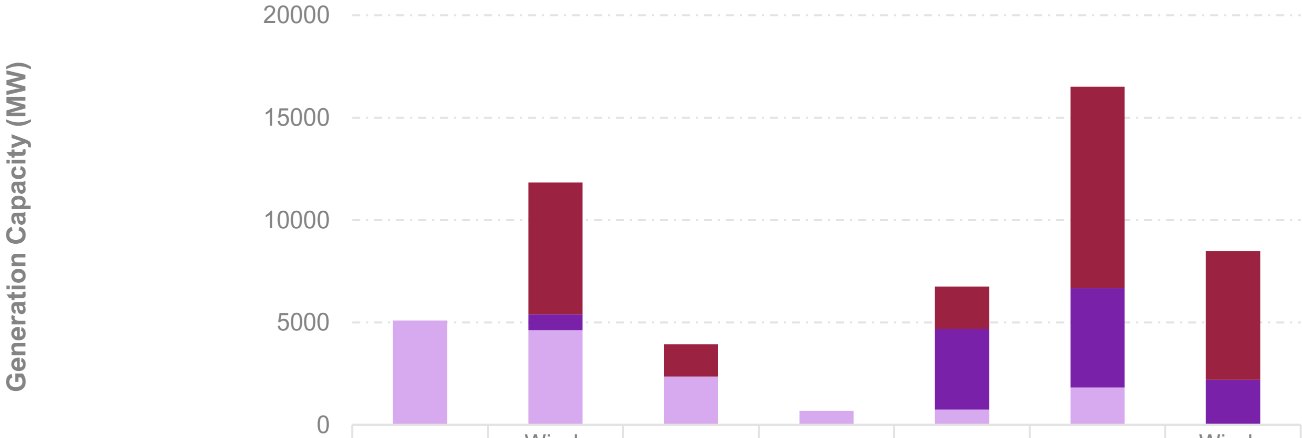
[40] The 2023 VAPR included both large-scale and distributed generation connections in its assessment criteria (NER 5.18A).

[41] See https://aemo.com.au/energy-systems/electricity/national-electricity-market-nem/participate-in-the-market/network-connections/register-of-large-generators---victoria.

  - 7.1 GW of large-scale wind, solar generation, and battery storage.
  - 0.7 GW of hydro generation.
- Thermal generation capacity 7.5 GW:
  - 5.1 GW of coal generation, of which 1.6 GW is announced to be retired in next 10 years.
  - 2.4 GW of gas generation.

There is a substantial pipeline of additional projects currently classed as proposed. **Figure 7** shows the additional new generation and storage committed and commissioned in the last 12 months, and the pipeline of connections that have been proposed but have not yet met the criteria to be classed as committed.

Figure 7 Total maximum capacity (MW) by count of projects by category



	Coal	Wind-Onshore	Gas	Hydro	Solar	BESS	Wind - Offshore
Enquiries		6442.2	1570		2053	9830	6282
Pre-Application/Application		767	0		3942	4848	2200
Existing/Committed	5095	4623	2358	678	748	1825	

Existing/Committed **Pre-Application/Application** **Enquiries**

2.5.1 Growing investments in renewable energy highlight challenges in Victoria's traditional transmission network

As Victoria decarbonises its energy system, the geographic location of supply has diversified. Additional solar and wind generation is being developed in the west of the state while large brown coal generators in the Latrobe Valley have identified expected closure dates. Solar and wind generation sources, including offshore wind, are also anticipated to develop in the east to take advantage of existing transmission resources.

Given the intermittent nature of solar and wind resources, both east and west generation developments will be required to meet the needs of Victorian consumers. While the network to the east is expected to largely accommodate generation developments replacing coal in the next decade, the network to the state's west does not have the capacity to transfer large quantities of the power from the renewable energy sources expected to connect in that area, which will lead to renewable generators being constrained in the short term (see Section

2.3.4 in the 2024 VNPIR[42] for information about the geographical shift in supply and its implications on network constraints).

Generation and storage update since the 2023 VAPR

Victoria has seen substantial additional wind and utility-scale solar projects either becoming committed or commissioned over 2023-24.

Table 2 lists newly committed large-scale renewable energy projects, currently in the commissioning phase since the publication of the 2023 VAPR, adding 1.2 GW of maximum capacity.

Table 2 Newly committed large-scale renewable projects since 2023 VAPR

Source	Project	Connecting terminal station	Connection voltage (kV)	Maximum capacity (MW)
Wind	Golden Plains Wind Farm – Stage 2	Cressy (new)	220	557
	Ryan Corner Wind Farm	Tarrone	132	205
Solar	Carwarp Solar Farm	Carwarp (new)	220	150
	Goorambat East Solar Farm	Goorambat East (new)	220	250
	Mokoan Solar Farm	Glenrowan	66	46

As **Table 3** shows, three large-scale renewable projects have been commissioned in the DSN in the past year, adding 360 MW of maximum capacity.

Table 3 Newly commissioned large-scale renewable projects since 2023 VAPR

Source	Project	Connecting terminal station	Connection voltage (kV)	Maximum capacity (MW)
Wind	Mortlake South Wind Farm	Terang	220	153
	Berrybank Stage 2 Wind Farm	Berrybank	220	105
Solar	Glenrowan Solar Farm	Glenrowan	220	102

In Victoria, storage projects totalling 0.4 GW have recently been commissioned, including Australia's largest lithium-ion battery (the Victorian Big Battery) to ensure continuity of supply and firming the intermittency of VRE. In addition to the recently connected storage projects, a further five projects (totalling 1.4 GW) reached commitment status in the past year, as shown in **Table 4**.

Table 4 Newly committed BESS projects since 2023 VAPR

Source	Project	Connecting terminal station	Connection voltage (kV)	Maximum capacity (MW)
BESS	Melton Renewable Energy Hub (MREH)	Sydenham	220	600
	Mornington BESS	Tyabb	220	240
	Terang BESS	Terang	220	100
	Pine Lodge BESS	Pine Lodge (new)	220	250

[42] See the *Victorian Network Performance and Insights Report*, at https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/nem-forecasting-and-planning/victorian-planning/victorian-annual-planning-report.

Source	Project	Connecting terminal station	Connection voltage (kV)	Maximum capacity (MW)
	Koorangie Energy Storage System[A]	Koorangie (new)	220	185

A. A project supported by the RDP Stage 1 projects. See section 3.1.2 for more details of this connection project.

2.6 Electricity consumption and demand trends and forecasts

The demand forecasts used for the 2024 Annual Planning Review are AEMO's 2024 *Electricity Statement of Opportunities* (ESOO) [43] Central scenario forecasts. Forecasts are sent out[44], meaning energy delivered from the transmission system to household and business consumers plus expected losses in transmission and distribution networks.

Operational consumption is defined as energy usage over a year, supplied through the transmission network and measured in megawatt hours (MWh).

Operational demand is defined as the level of electricity drawn from the transmission network, measured in megawatts (MW), averaged from the power system in half-hour intervals.

Underlying consumption/demand means all the energy used, including that supplied by distributed PV.

Part of this chapter will cover analysis and explanation of how the 2024 forecasts compare to 2023 forecasts. Consumption and demand forecasts are updated using the latest data on economic and population drivers as well as trends in behaviour by household and business consumers, including electrification impacts. The forecasts factor in projections for energy efficiency measures and growth in CER, including distributed PV generation, BESS and EVs, which all impact how much energy needs to be supplied from the grid.

2.6.1 Annual operational consumption forecast

Figure 8 shows Victoria's component forecasts containing operational consumption, small-scale generation[45] and energy efficiency that make up the operational (sent out) consumption under the 2024 ESOO Central scenario. Under this scenario, AEMO projects:

- A gradual increase in consumption in the first five years due to business sector growth, partially offset by residential and business PV.
- From years 6 to 10, consumption increasing significantly, driven by growth in domestic hydrogen production, and by continued adoption of EVs. Additionally, EV adoption continues to increase, although more slowly than was initially anticipated in the 2023 ESOO forecasts.
- From years 11 to 30, consumption continuing to grow, driven by electrification in the residential and business sector, EV adoption and the growth of domestic hydrogen production, offset by energy efficiencies and PV uptake. Starting from financial year 2040-41, residential energy consumption is forecast to become negative,

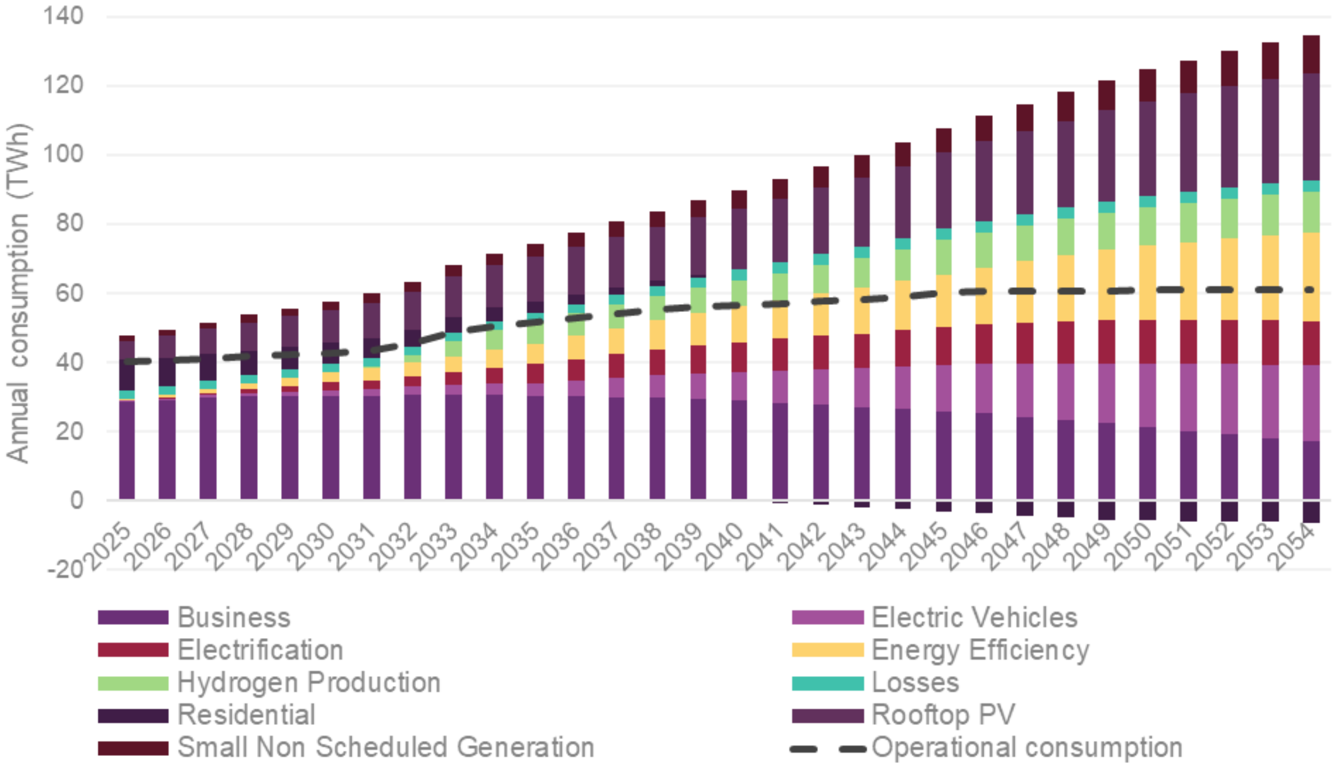
[43] See https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/nem_esoo/2024/2024-electricity-statement-of-opportunities.pdf.

[44] See https://www.aemo.com.au/-/media/Files/Electricity/NEM/Planning_and_Forecasting/Demand-Forecasts/Operational-Consumption-definition.pdf.

[45] Distributed PV, small non-scheduled generation and hydrogen production.

driven by the continued growth of distributed PV generation from households installing larger PV systems, along with improvements in energy efficiency.

Figure 8 Victorian electricity annual energy consumption forecast, 2024 ESOO Central, operational (sent out)



Compared to the 2023 ESOO, the updated 2024 ESOO forecasts lower growth in Victoria's annual energy consumption than previously anticipated. This revision is driven by factors such as:

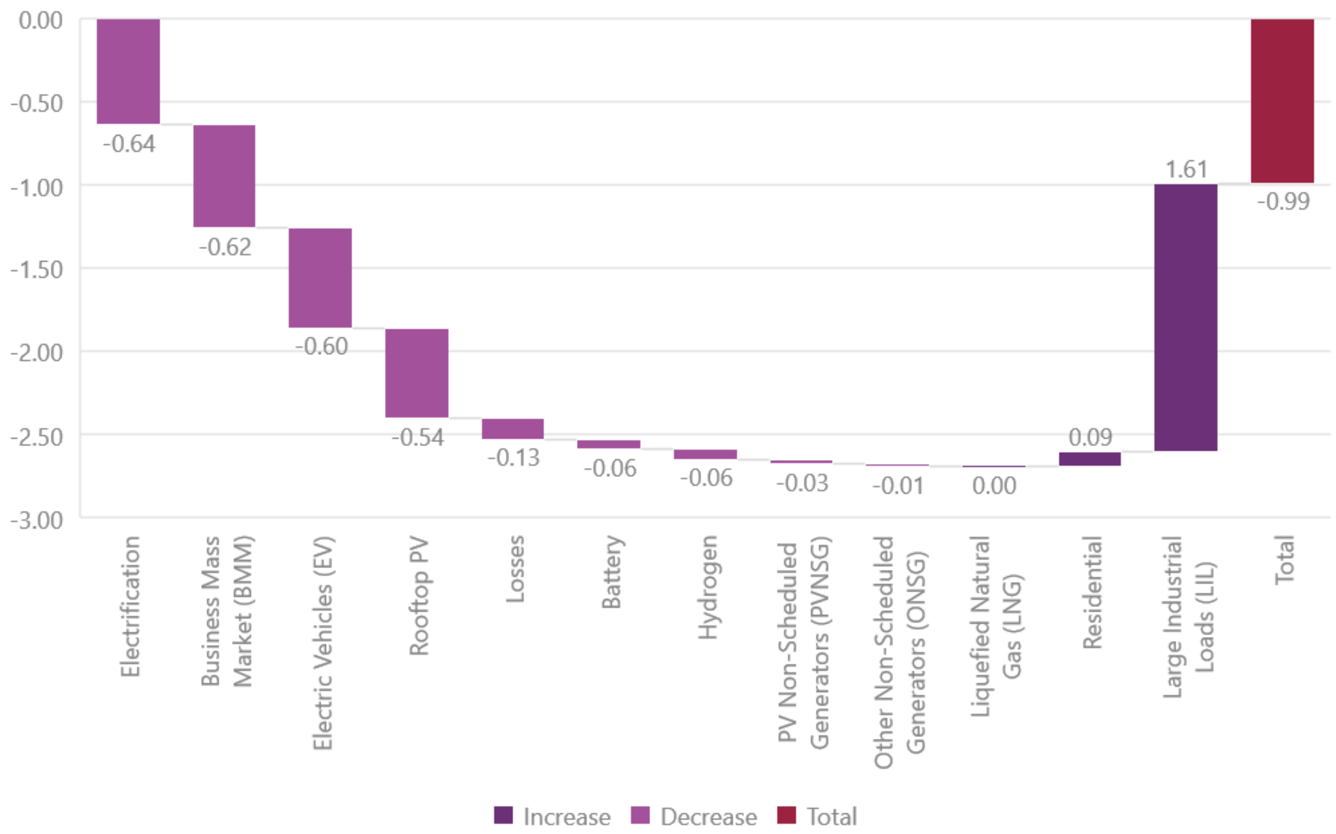
- Slower projected adoption of EVs.
- Slower forecast economic growth impacting small to medium business.
- Higher forecast for distributed PV.
- Forecast increased investment in data centres becoming a key driver of energy consumption particularly in Melbourne[46].

2.6.2 Factors influencing changes between 2023 and 2024 consumption forecasts

Using the 2023 and 2024 ESOO consumption forecasts, **Figure 9** illustrates the key factors driving the changes in Victorian consumption projections for 2028-29.

[46] See https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/nem_esoo/2024/2024-electricity-statement-of-opportunities.pdf.

Figure 9 Comparison for 2028-29 between the 2023 and 2024 ESOO consumption forecasts, Central – *Step Change* scenario



The factors driving the changes between the 2023 and 2024 ESOO consumption forecasts for 2028-29 are:

- Increases in large industrial loads (LILs), primarily due to the growth of data centres in Victoria. Since the last VAPR, enquiries into data centre connections amounted to an approximate 4 GW of load, mainly concentrated in the western metropolitan areas of Melbourne. These enquiries have not been included in the 2024 ESOO demand forecasts.
- A weaker economic outlook hindering growth in the Business Mass Market (BMM) sector.
- The Federal Government's revised New Vehicle Efficiency Standard (NVES) which provides flexible emission reductions for the non-EVs and reduced zero emission targets beyond 2029. This amendment has led to reduced EV uptake projections. [47,48]
- The updated PV forecasts, which reflect a trend towards larger rooftop systems. While PV systems significantly offset both residential and business consumption, the impact on peak demand is only marginally reduced.

Figure 10 illustrates the factors influencing the revised ESOO consumption forecasts under the ESOO Central scenario for 2033-34. The revised forecasts are significantly lower than 2023 ESOO forecasts, primarily due to:

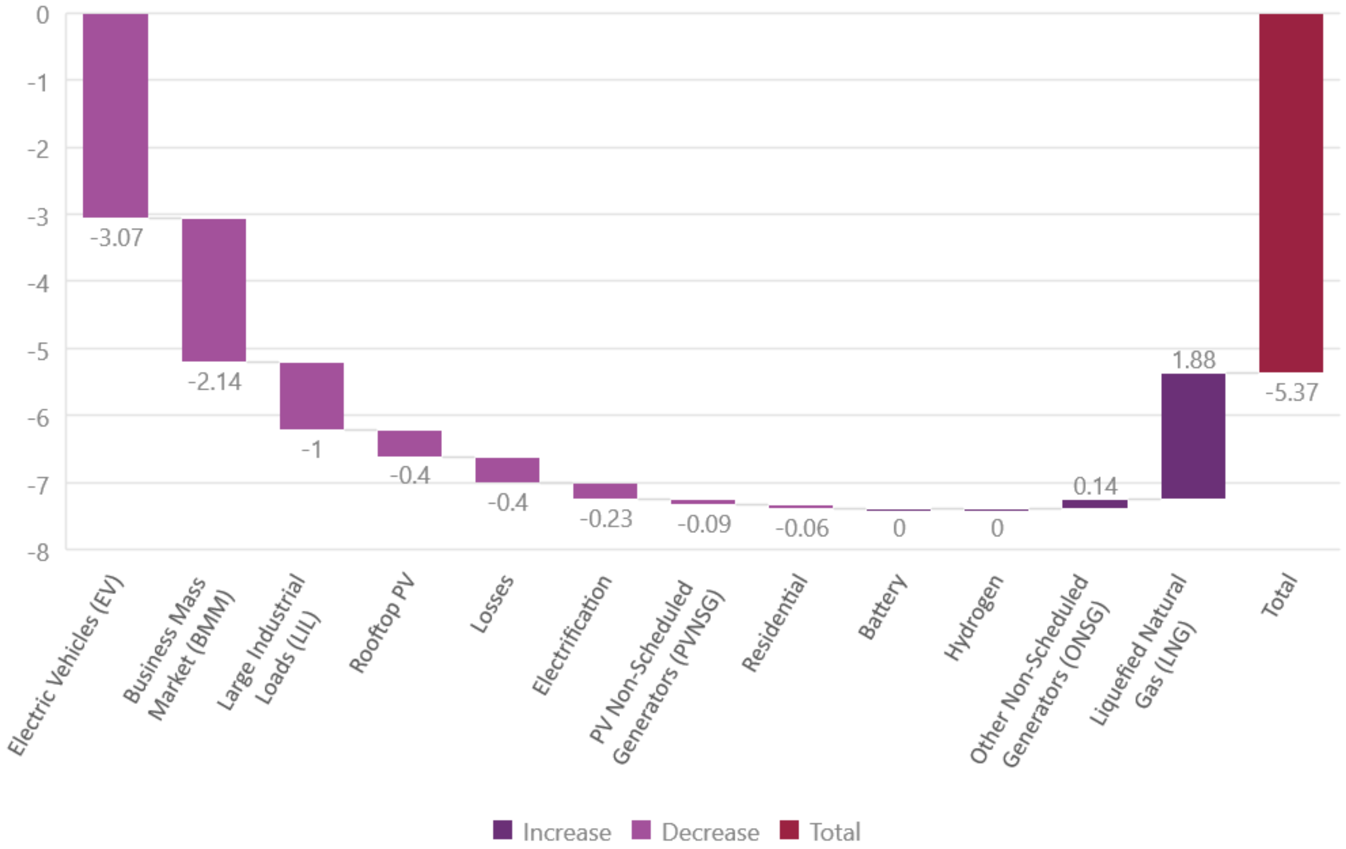
- Slower EV adoption forecasts.

[47] See NVES at Federal Register of Legislation - New Vehicle Efficiency Standard Act 2024

[48] 2024 ESOO at https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/nem-forecasting-and-planning/forecasting-and-reliability/nem-electricity-statement-of-opportunities-esoo

- A weaker economic outlook in the 2030s, which is expected to cause BMM growth to plateau.
- The continued adoption of larger PV systems is projected to offset consumption growth in the 2030s.

Figure 10 Comparison for 2033-34 between the 2023 and 2024 ESOO consumption forecasts, Central – *Step Change* scenario



2.6.3 Electricity demand forecasts

Maximum and minimum operational demand means the highest and lowest level of electricity drawn from the transmission system, measured, and averaged in half-hour intervals in either summer (November to March) or winter (June to August).

In 2023-24, the maximum demand of 9,294 MW occurred on 22 February 2024, compared to the peak of 8,988 MW in 2022-23. While summer operational maximum demand increased from the past year, it remained relatively low, driven by mild weather conditions and increasing uptake of distributed PV.

Victoria recorded its all-time lowest minimum operational demand of 1,564 MW on Sunday 31 December 2023 at 1300 hrs[49]. This was 631 MW lower than the previous record set last financial year.

See the *Victorian Network Performance and Insights Report*[50] for more details about demand and consumption in 2023-24.

[49] See Page 10 at https://aemo.com.au/-/media/files/major-publications/qed/2023/quarterly-energy-dynamics-q4-2023.pdf.

[50] See https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/nem-forecasting-and-planning/victorian-planning/victorian-annual-planning-report.

Maximum and minimum operational demand forecasts can be presented with:

- A 50% probability of exceedance (POE), meaning they are expected statistically to be met or exceeded one year in two, and are based on average weather conditions (also called one-in-two-year).
- A 10% POE (for maximum demand) or 90% POE (for minimum demand), based on more extreme conditions that could be expected one year in 10 (also called one-in-10-year).

Maximum demand forecast is steadily increasing, but at a lower rate than projected last year

The latest 10% POE and 50% POE maximum demand forecasts for Victoria are illustrated in **Figure 11** andFigure 11Figure 12 **Figure 12** respectively. The figures also compare the 2023 and 2024 forecasts, showing that projected softening of EV demand, coupled with a less optimistic economic outlook, has led to lower long-term demand forecasts compared to 2023.

Key insights are:

- For the next decade, both 10% and 50% POE demand forecasts for Victoria are summer peaking.
- For the first five years, maximum demand forecasts show a steady increase. The 2024 forecasts are slightly higher than the 2023 projections, primarily due to the growth of LILs, especially data centres.
- A downward revision in EV adoption and lower growth expectations from BMM sector caused the 2024 ESOO maximum demand forecast to trend lower than the 2023 ESOO maximum demand forecasts from 2028 onwards.

Figure 11 Actual and forecast maximum demand (MW) in 2023 and 2024 ESOO Central (10% POE, operational sent out), 2019-20 to 2033-34

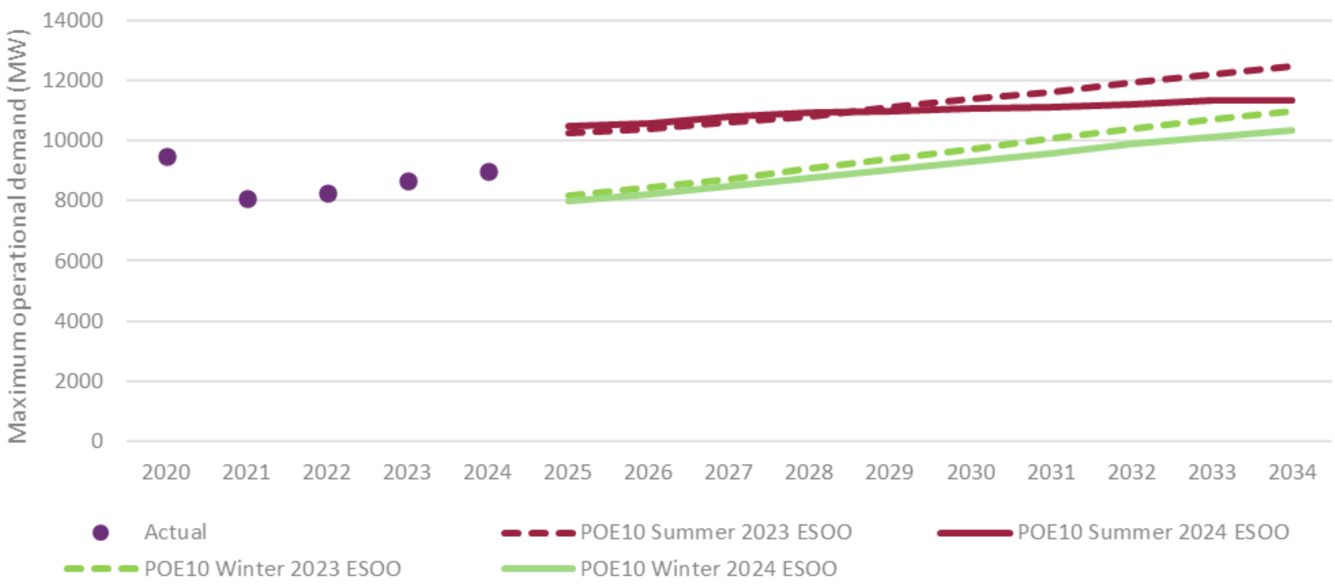
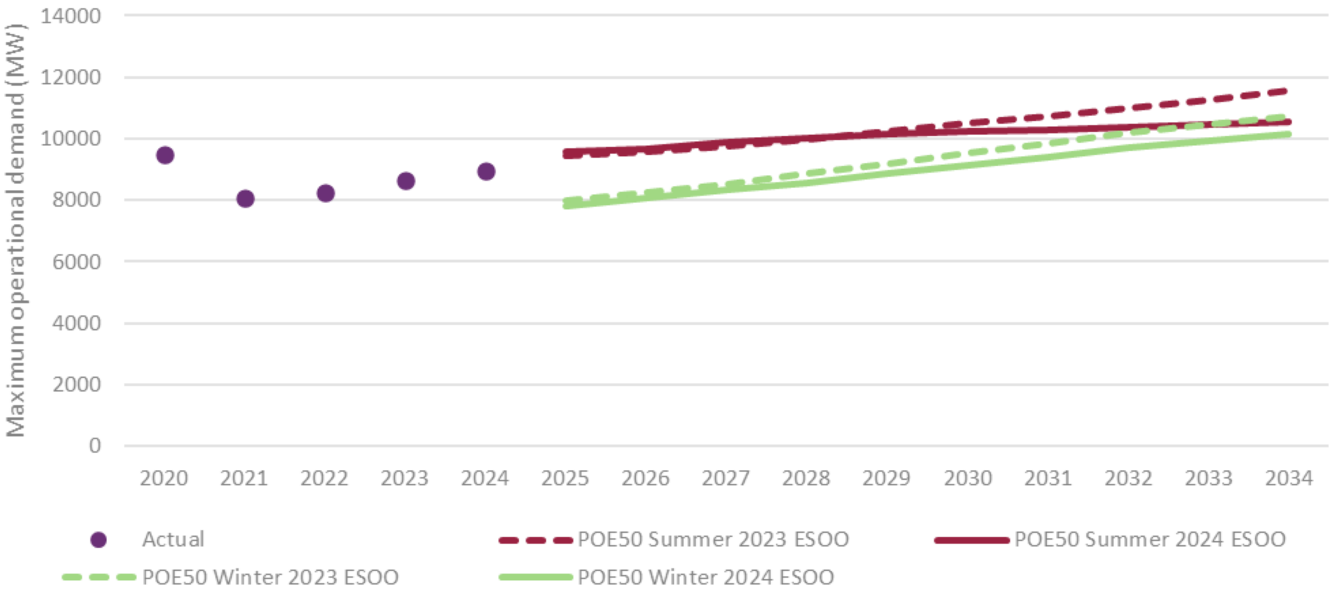


Figure 12 Actual and forecast maximum demand (MW) in 2023 and 2024 ESOO Central (50% POE, operational sent out), 2019-20 to 2033-34



Minimum demand forecast is declining, and is projected to be lower than forecast last year

Minimum operational demand is strongly correlated to PV capacity, with minimums often occurring during daytime hours. The demand forecasts have been revised to account for the upward trend towards larger distributed PV systems, which is expected to offset demand from 2029-30.

Figure 13 shows the 90% POE minimum demand forecasts, which continue a downward trend, attributable to higher rooftop PV forecasts**.** Minimum demand forecasts are lower compared to 2023, due to projections for lower EV adoption and weaker economic conditions[51].

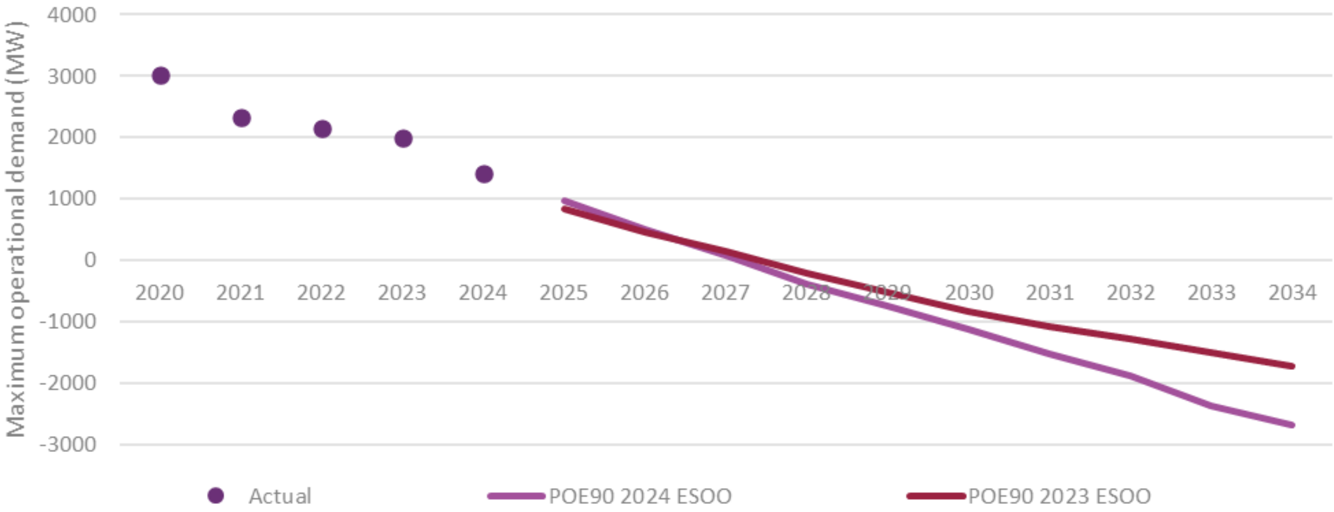
Under the ESOO Central scenario at the 90% POE forecast level, key insights are:

- Minimum demand is anticipated to fall below zero by 2027-28.
- Between 2024-25 and 2033-34, minimum demand will drop an average of 402 MW at 90% POE, year on year.
- By 2033-34, minimum demand is anticipated to fall below -2.6 GW[52].

[51] See https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/nem_esoo/2024/2024-electricity-statement-of-opportunities.pdf.

[52] For more information on how AEMO manages minimum system load, see https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/system-operations/power-system-operation.

Figure 13 Actual and forecast minimum demand (MW) in 2023 and 2024 ESOO Central (90% POE, operational sent out), 2019-20 to 2033-34



3 Transmission Development Plan for Victoria

This section outlines AVP's updated 10-year Transmission Development Plan to support reliable, secure, and affordable electricity for Victoria, provides information about key network developments underway and planned for the Victorian DSN as part of the Transmission Development Plan, and discusses changes in the plan since the 2023 VAPR.

Key insights

- The Transmission Development Plan for Victoria is designed to deliver security and reliability objectives in the context of Victorian Government policy and regulatory settings. The investment projects presented in the plan help reduce overall costs to consumers by unlocking lower-cost generation supplies, maintain the reliability of the electricity supply to the Victorian consumers while ensuring power system resilience, and improve the efficiency of resource sharing between neighbouring regions. As such, delivering these investments is critically important to meet Victoria's energy reliability and security requirements.
- The majority of the network and non-network developments currently being progressed in Victoria through its Transmission Development Plan, such as RDP Stage 1 projects, Western Renewables Link (WRL) and Victoria – New South Wales Interconnector West (VNI West), serve to reduce congestion and improve the system strength of the DSN to harness renewable generation developments for consumers.
- Regulatory tests are underway to:
  - Manage the voltages in metropolitan Melbourne during high and low demand conditions. The Project Draft Assessment Report (PADR) of the Melbourne Metropolitan Voltage Management Regulatory Investment Test was published in July 2024. AVP is working towards the final stage of the RIT-T and aims to publish the PACR in later this year.
  - Maintain required system strength services across the DSN under the revised system strength rules. AVP is planning to publish the PADR by April 2025.
  - Reinforce the 220 kV ring in Eastern and Western metropolitan Melbourne DSN.
- Together these projects target key thermal, stability, voltage control, system strength, and REZ expansion limits across the state and interconnector transfer limits with neighbouring states.
- The Transmission Development Plan is updated annually after undertaking the Annual Planning Review presented in Section 4.

AVP's annual 10-year Transmission Development Plan consists of network augmentation projects identified as part of annual transmission planning process and additional augmentations and operational arrangements initiated by the government via NEVA orders and market investors as part of large generator/storage or load connections.

This plan is reviewed and updated each year as part of the VAPR. Over the 10-year outlook, these projects will facilitate the connection of new generation, increase network capacity to transfer power between new supply centres and demand, and manage emerging operational challenges. Combined, these projects help efficiently deliver network performance as outlined in the NER, maintain supply reliability, and minimise overall costs to consumers in the context of Victorian Government policy and regulatory settings.

As the jurisdictional planner for the DSN in Victoria, AVP is committed to reviewing and improving the development plan for the DSN to deliver reliable, secure and affordable energy to consumers while enabling the energy transition.

To address emerging operational challenges and deliver a system capable of facilitating the supply and demand changes highlighted in Section 2, AVP has been progressing a suite of transmission development projects.

Figure 14Figure 14 and **Figure 15** show the projects included in the updated Transmission Development Plan for Victoria. **Figure 16** illustrates the in-progress projects in the Transmission Development Plan in a timeline.

These projects are either:

- **Completed projects** – projects that have completed the delivery stage since the publication of 2023 VAPR.
- **Projects in delivery stage** – projects that have completed the regulatory tests or other planning approval and current have progressed to detailed scoping and design stage.
- **Other planned projects** – all committed and anticipated projects according to the ISP commitment criteria in the ISP Methodology[53], as well as transmission projects initiated by VicGrid as part of the RDP.

AVP's Transmission Development Plan for Victoria assesses limitations identified in the Annual Planning Review and is designed to meet security and reliability objectives in an efficient way over the coming decade. This means it is not necessarily designed to remove all network limitations, particularly where generation investments occur in weaker parts of the grid, resulting in generation curtailment or where the costs of augmentation outweigh the benefits to consumers.

In parallel to AVP's Transmission Development Plan for Victoria, VicGrid develops the Victorian Transmission Plan (VTP), which is a plan to identify ways to expand development of REZs and address network limitations that result in excessive generator curtailment.

AVP proactively identifies and monitors future limitations through its planning and connection functions as well as interfaces with the operational teams, which could trigger further investigations under specific system changes or generator investment patterns.

The VAPR uses detailed analysis to capture the nature, timing, impact, and triggers associated with potential limitations, which identify the need for network investment and informs the subsequent ISP. The focus of this work is on identifying projects that are likely to deliver net positive economic benefits under the current regulatory framework, or where corrective action is required to keep the DSN reliable and secure.

Section 3.1 of the VAPR provides more detail about projects, including high-level scope and progress since the 2023 VAPR.

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

Figure 14 Newly completed/approaching completion Transmission Development Plan projects for Victoria

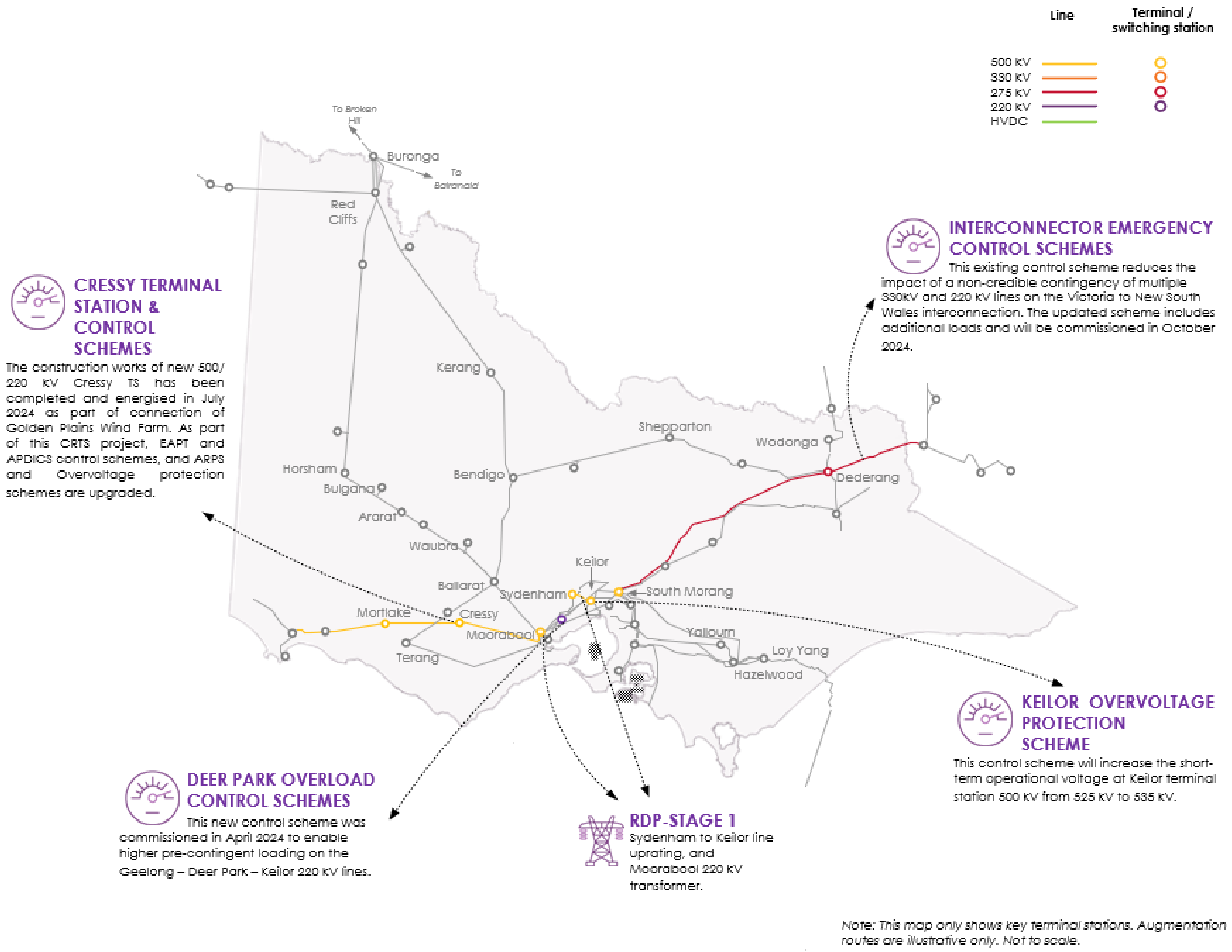


Figure 15 In progress Transmission Development Plan projects for Victoria

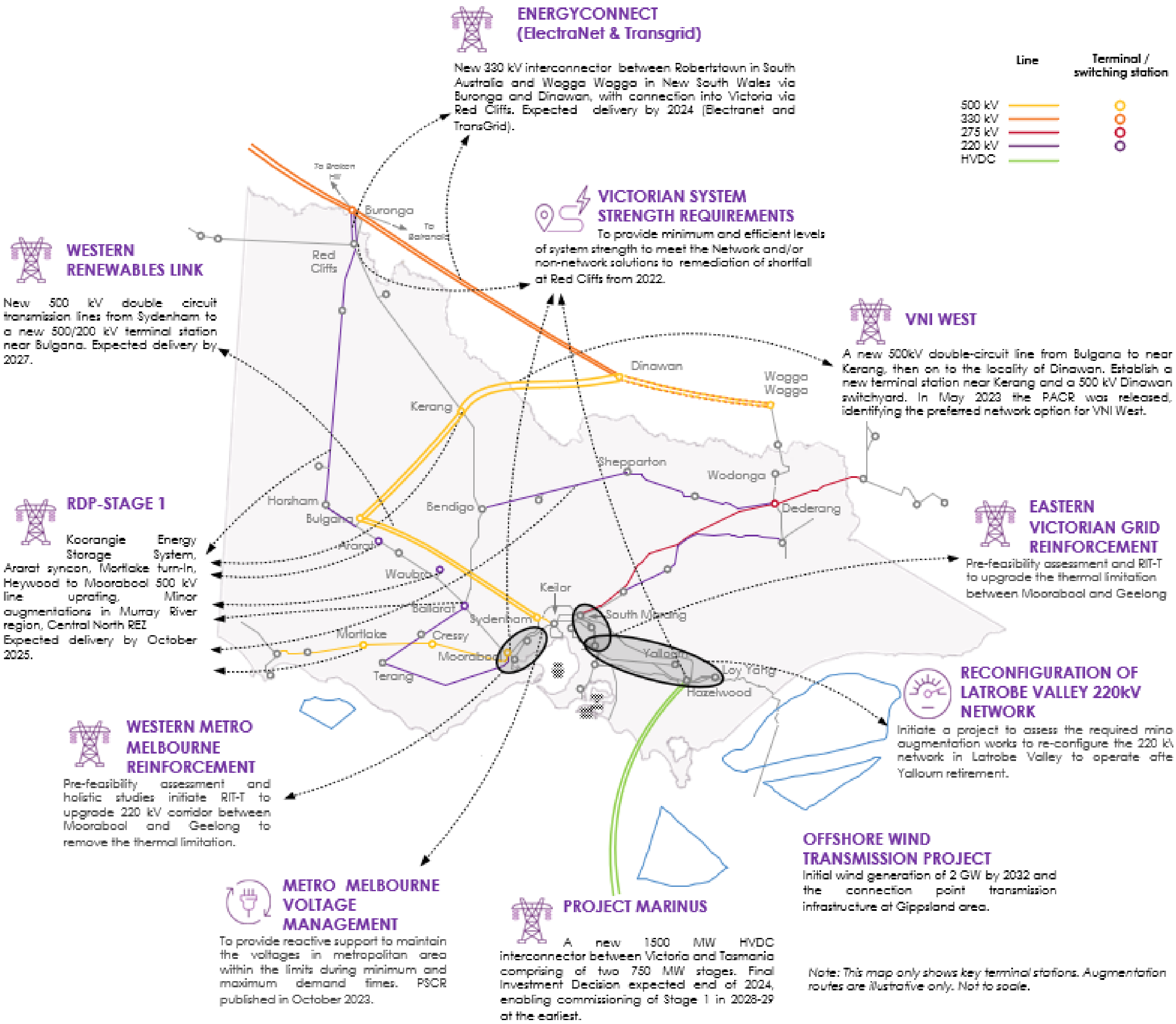
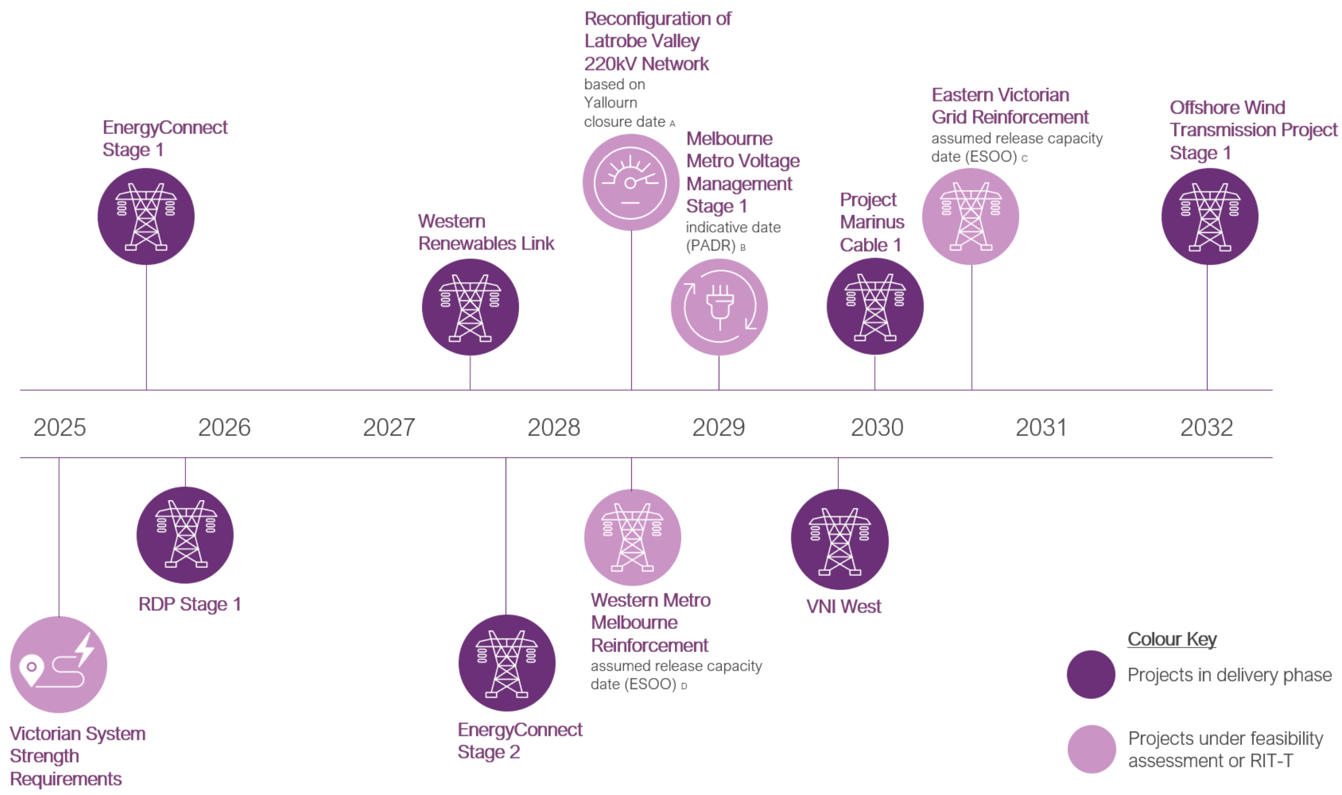


Figure 16 Timeline of Transmission Development Plan projects for Victoria



A. See https://www.aemo.com.au/energy-systems/electricity/national-electricity-market-nem/nem-forecasting-and-planning/forecasting-and-planning-data/generation-information.
B. See https://aemo.com.au/-/media/files/initiatives/metropolitan-melbourne-voltage-management-rit/melbourne-metropolitan-voltage-management-project-assessment-draft-report.pdf.
C. See page 79 https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/nem_esoo/2024/2024-electricity-statement-of-opportunities.pdf.
D. See page 79 https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/nem_esoo/2024/2024-electricity-statement-of-opportunities.pdf.

3.1 Major projects in the Transmission Development Plan

3.1.1 Completed projects since 2023 VAPR

The following projects have completed construction works and been delivered since the 2023 VAPR.

New terminal stations in the DSN

- 500/220 kV Cressy Terminal Station (TS) including two 500/220 kV transformers – construction works for the new 500/220 kV Cressy TS have been completed and energised in July 2024 as part of connection of Golden Plains Wind Farm. The Cressy TS ties in both 500 kV lines between Moorabool to Mortlake and Haunted Gully terminal stations strengthening the existing 500 kV corridor.

Control schemes

- As part of the Cressy TS project, AVP upgraded existing control schemes in South Western Victoria, including South West Generation Fast Tripping (SW500 GFT), Emergency Alcoa Potline Trip (EAPT), Anti Resonance Protection Scheme (ARPS), APD Inter-trip Control Scheme (APDICS) and a number of Overvoltage Protection Schemes (OVPS).

- Deer Park System Overload Control Scheme (SOCS) – this control scheme was commissioned in April 2024 to enable higher pre-contingent loading on the Geelong – Deer Park – Keilor 220 kV lines, alleviating constraints on the Geelong and Keilor 220 kV corridor.

3.1.2 Transmission augmentation projects already underway

Projects in delivery stage

The following sections describe transmission augmentation projects already in delivery stage to alleviate the previously identified network constraints in the DSN.

REZ Development Plan (RDP) Stage 1 projects

The Victorian Government's RDP Directions Paper[54] published in February 2021 identified potential network augmentations that would relieve existing constraints on the Victorian DSN and facilitate the connection of future generators.

In late 2021, the Victorian Government directed AVP to progress procurement activities for three contestable projects for services to strengthen the system, as well as three sets (totalling nine projects) of non-contestable minor network augmentations

In 2022, the Victorian Government also directed AVP via REZ Stage 1 *National Electricity (Victoria) Act 2005* (NEVA) Orders to progress procurement activities and enter into contracts with the declared transmission system operator. This directive was for the network augmentations identified during the procurement process[55] for turn-in of the Haunted Gully to Tarrone 500 kV line at Mortlake.

0 summarises major projects currently being delivered under the RDP Stage 1 to strengthen the existing DSN to enable additional renewable generation connections.

[54] See https://www.energy.vic.gov.au/__data/assets/pdf_file/0016/512422/DELWP_REZ-Development-Plan-Directions-Paper_Feb23-updated.pdf.

[55] Victoria Government Gazette No. S547, 14 October 2022, at http://www.gazette.vic.gov.au/gazette/Gazettes2022/GG2022S547.pdf.

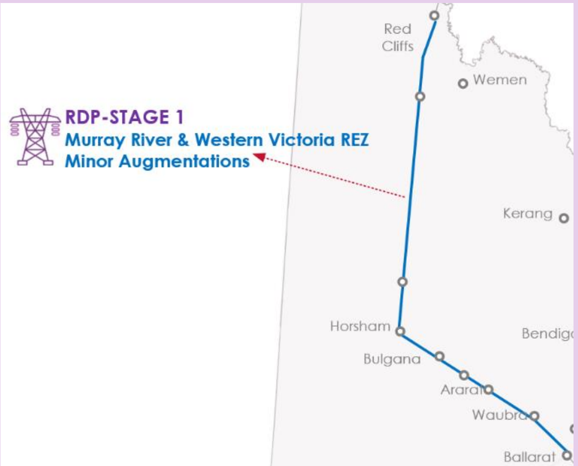
Table 5 RDP Stage 1 system strengthening projects

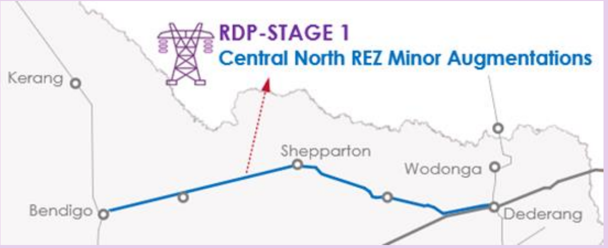
Project	REZ	Purpose	Description and scope
Mortlake Turn in	V4 – South West	Improving voltage stability in the South West REZ to increase the potential for connection of additional renewable generation. Mortlake Turn in has the potential to allow up to 1,500 MW of additional renewable generation on optimal conditions and 1,100 MW on a peak summer demand periods[A].	• Connecting the existing Haunted Gully to Tarrone 500 kV circuit, of the Moorabool to Heywood 500 kV double circuit line, into Mortlake Power Station to establish a Haunted Gully to Mortlake 500 kV circuit and a Mortlake to Tarrone 500 kV circuit. • The project is expected to be completed by October 2025.
Koorangie Energy Storage System (KESS)	V2 – Murray River	Improving the system strength in Murray River REZ to increase the potential for connection of additional renewable generation. Additional renewable generation up to 300 MW can be supported by the KESS with the support of its grid-forming technology.	• Establishing a new 220 kV terminal station, located approximately 15 km north-west of the existing Kerang Terminal Station, connecting into the existing Kerang – Wemen 220 kV line. • Establishing a new 125 MW/250 MWh battery energy storage system with grid-forming inverters. • The project is expected to be completed by mid-2025. The KESS will provide system strength services for 20 years as part of the service agreement with AEMO[B].
Ararat synchronous condenser	V3 – Western Victoria	Improving the system strength in Western REZ and providing dynamic voltage and reactive power control capability. Ararat synchronous condenser is expected to allow the stable connection of up to 600 MW of additional renewable generation.	• Installation of a synchronous 250 megavolt amperes (MVA) synchronous condenser and the associated primary and secondary equipment at existing Ararat Terminal Station. • Expected completion date of the project is early 2026 with a 20-year service agreement[C].

A. See https://aemo.com.au/en/newsroom/media-release/aemo-completes-procurement-for-victorian-government.
B. See https://aemo.com.au/en/newsroom/media-release/aemo-awards-contract-to-improve-system-security-in-murray-river-rez.
C. See https://aemo.com.au/en/newsroom/media-release/aemo-awards-contract-to-improve-system-security-in-western-victoria-rez.

Table 6 below provides a summary of the minor augmentations to be carried out in West Murray, South West and Central North REZs in Victoria as part of RDP Stage 1. The purpose of these minor augmentations is to alleviate the existing thermal constraints to allow additional low-cost renewable generation in regional Victoria to connect to the NEM. As **Table 7** indicates, some of these projects have been already completed, however, to deliver the full benefits within each REZ, all elements of the relevant REZ need to be completed. These RDP Stage 1 minor augmentations are expected to be completed by October 2025.

Table 6 Summary of RDP Stage 1 minor augmentation projects – all projects aimed at relieving thermal constraints

REZ	Project	Description and scope of work	Status
V4 – South West 	• Ballarat – Terang – Moorabool thermal loading control scheme	• Implementing an automatic generator runback control scheme to avoid thermal overloading on Ballarat – Berrybank – Terang – Moorabool 220 kV link post contingency (trip of Ballarat to Berrybank 220 kV line).	In Progress
	• Heywood to Moorabool 500 kV line uprating (substation/auxiliary upgrade and dynamic line rating)	• Install wind monitoring facilities to realise higher thermal capacity ratings. • Upgrade interplant limitations (such as switch to circuit breaker conductor sections) within the Moorabool and/or Heywood terminal station/s to increase the Heywood to Moorabool 500 kV line rating.	In Progress
	• Sydenham to Keilor line uprating (station upgrade)	• Upgrade interplant assets to remove the limitations (such as switch to circuit breaker conductor sections) within the Sydenham and/or Keilor terminal station/s to increase the Sydenham to Keilor 500 kV line rating.	Completed
	• Moorabool 220 kV transformer (MLTS) station upgrade	• Upgrade interplant limitations (such as switch to circuit breaker conductor sections) within MLTS to match MLTS transformer short-term ratings.	Completed
V2 – Murray River **V3 – Western Victoria** 	• Red Cliffs – Kiamal – Murra Warra – Horsham – Bulgana thermal loading control scheme	• Install a generator runback/tripping scheme to quickly reduce the output of local generators to avoid overload of the Red Cliffs – Kiamal – Murra Warra – Horsham – Bulgana 220 kV lines. This scheme is expected to operate to prevent overload following trip of either Bendigo – Kerang 220 kV line or Red Cliffs – Wemen – Kerang 220 kV line.	In Progress
	• Red Cliffs – Kiamal – Murra Warra – Horsham – Bulgana thermal overloading control scheme with Murraylink very fast runback for Murraylink import conditions	• Modify the existing Murraylink Very Fast Run Back (VFRB) to operate during Murraylink on import (from South Australia to Victoria) to manage thermal loading on Red Cliffs – Kiamal Murra Warra – Horsham – Bulgana 200 kV link during contingency conditions.	In Progress
	• Ararat, Waubra, Ballarat, Bulgana and Kiamal terminal station interplant upgrades	• Upgrade interplant limitations at Ararat, Waubra, Ballarat, Bulgana and Kiamal to allow full utilisation of the 220 kV line ratings.	In Progress

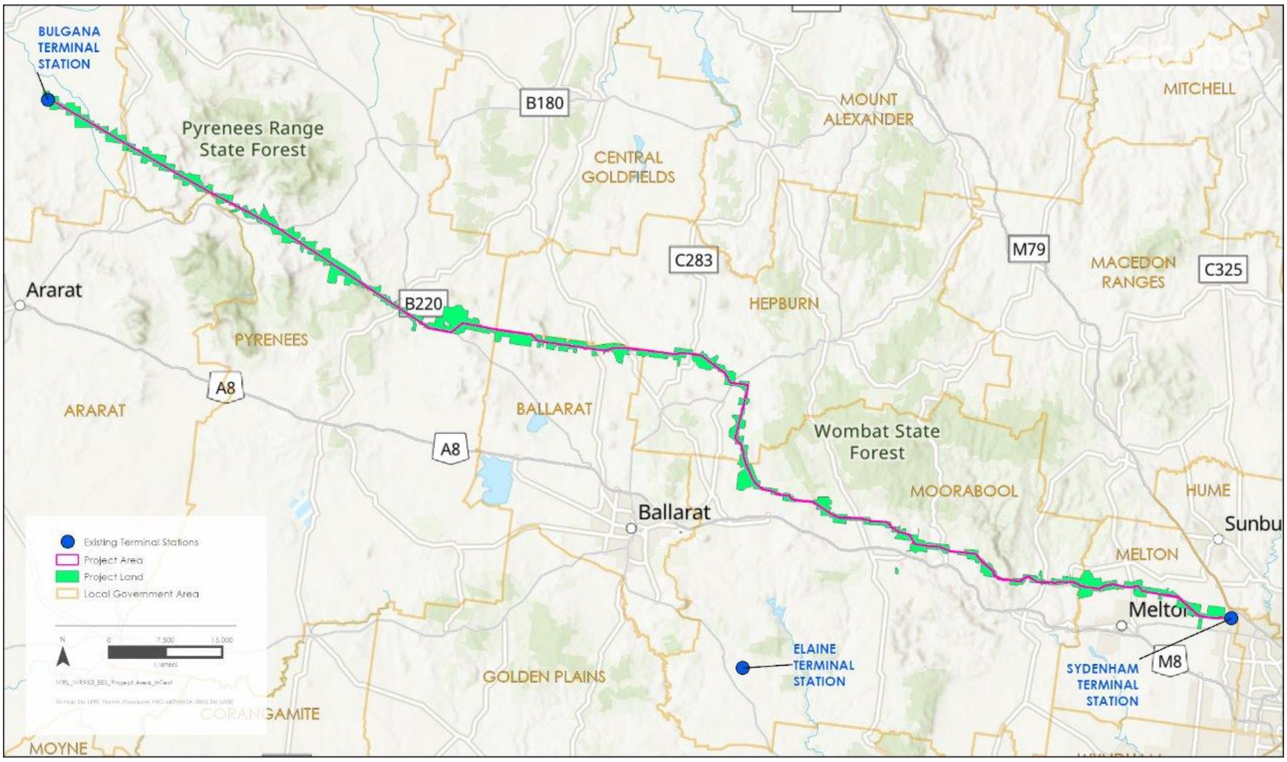
REZ	Project	Description and scope of work	Status
V1 and V6 	• Dederang – Glenrowan – Shepparton– Bendigo circuit thermal loading control scheme	• Implementing an automatic generator runback control scheme to manage the thermal loading in 220 kV lines between Dederang and Bendigo for runback of the proposed Axedale Solar Farm. This scheme is expected to operate to prevent overload following trip of either: • Eildon – Thomastown 220 kV line. • Bendigo – Kerang 220 kV line. • Dederang H1 Dederang Bus Splitter Scheme (DBUSS) operation. • Fosterville – Shepparton 220 kV line.	In Progress
	• Central North REZ augmentation #2: Dederang TS 330 / 220 kV transformer (secondary cooling system)	• Install a remote control that automates the enablement of the cooling system on the Dederang TS (DDTS) H3 transformer, thereby allowing the 340 MVA short-term rating to be available at all times.	In Progress

Western Renewables Link (WRL)

In 2019, AVP completed the Western Victoria Transmission Network Project RIT-T to unlock renewable energy resources, reduce network congestion, and improve utilisation of existing assets in western Victoria[56]. AusNet Services was then awarded a contract to develop the project and seek planning approvals in order to build, own, operate and maintain the preferred transmission augmentations identified for WRL by the RIT-T.

In May 2023, following investigations in relation to the VNI West transmission project and the release of the VNI West PACR, the Victorian Minister for Energy and Resources Issued order S 267, 27 May 2023 (May NEVA Order) in relation to WRL and VNI West. The effect of the May NEVA Order is to allow the WRL Project to proceed based on a modified scope including the construction of a new 500 kV double circuit transmission line from Sydenham to Bulgana (referred to as the uprate). The order explains why such a course is justified and directs AVP to proceed with an uprated scope for the project. Due to the assessment of the augmented scope, pending project assessment and approvals, delivery of WRL is expected to be in mid-2027 rather than its original mid-2026 completion date.

Figure 17 Project overview map of WRL



The updated scope of WRL consists of:

- Extension of the 500 kV Sydenham TS (SYTS) by two breaker and a half switched bays; an additional 500 kV switched bus connected reactor sized approximately 100 megavolt amperes reactive (MVAr).

[56] See https://www.aemo.com.au/-/media/Files/Electricity/NEM/Planning_and_Forecasting/Victorian_Transmission/2019/PACR/Western-Victoria-RIT-T-PACR.pdf.

- Establishment of a new 500/220 kV TS (BXTS) located near the existing Bulgana 220 kV TS (BGTS), including a double switched (future breaker-and-a-half) 500 kV switchyard, installation of two new 1,000 megavolt amperes (MVA) 500/220 kV transformers and provision for the future development of a 220 kV switchyard.
- Construction of a new 500 kV double circuit transmission line from SYTS to BXTS, with 70 MVAr line shunt reactors connected to each circuit at both BXTS and SYTS.
- Redevelopment of the existing 220 kV Bulgana TS (BGTS), including the expansion of the existing single busbar 220 kV switchyard to a two busbar breaker-and-a-half switching arrangement and changed bay terminations for the existing BGTS-HOTS (Horsham) and BGTS-CWTS (Crowlands) 220 kV transmission lines and the Bulgana Wind Farm transformer connections.
- Construction of a new 220 kV double circuit transmission line from BGTS to BXTS.
- The addition of two physically independent route communication links between BGTS and BXTS, and between BXTS and SYTS.
- Cut-in, termination and switching of the existing Ballarat to Moorabool No. 2 220 kV transmission line at Elaine TS (ELTS), forming Ballarat to Elaine No. 2 line and Elaine to Moorabool No. 2 line. Re-alignment and switching of the existing Ballarat to Elaine transmission line and Elaine to Moorabool transmission lines at ELTS and renaming them to Ballarat to Elaine No. 3 line and Elaine to Moorabool No. 3 line.
- Interface activities at various terminal stations including, but not limited to:
  - System protection control scheme requirements. AVP is investigating the need for a new control scheme to prevent system instability and cascade tripping following a non-credible contingency of tripping both 500 kV circuits between BXTS and SYTS.
  - Minor augmentations at existing terminal stations (unless mentioned above) impacted by the above works.

The proposed VNI West transmission line is planned to connect to the proposed new terminal station near Bulgana (BXTS). The proposed WRL can function independently and is not dependent on the completion of VNI West.

AVP and AusNet Services have been engaging with landholders in the area for some time as well as undertaking field surveys and investigations to identify a suitable site for the new terminal station.

AVP and AusNet Services are currently working toward finalising and submitting the Western Renewables Link Environment Effects Statement (EES) to the Victorian Government. AVP expects the public exhibition and EES panel inquiry, which includes a public hearing, will take place throughout 2025.

The latest project information is available on AusNet Services' dedicated project website[57].

Victoria – New South Wales Interconnector West (VNI West)

VNI West is a proposed new high capacity 500 kV double circuit overhead transmission line, which will deliver vital new transmission infrastructure to:

[57] See https://www.westernrenewableslink.com.au.

- Carry clean low-cost renewable power from REZs in New South Wales and Victoria, in particular the wind and solar-rich regions of the Murray River REZ and the Western Victoria REZ.
- Harness upwards of 3.4 GW of new renewable generation in the Murray River and Western Victoria REZs.
- Add 1.93 GW of electricity export capacity from Victoria to New South Wales, and 1.67 GW of electricity import capacity from New South Wales to Victoria.
- Improve security and reliability in the electricity network as coal-fired power stations retire.

In May 2023, AVP and Transgrid released the Project Assessment Conclusions Report[58] (PACR) which identifies the preferred network option for VNI West, charting a broad corridor that connects it to WRL at a new terminal station at or near Bulgana, and crosses the Murray River north of Kerang to connect it to project EnergyConnect in New South Wales at the new Dinawan substation. The preferred network option in the PACR is known as Option 5A.

Transmission Company Victoria (TCV) has been established to undertake early works in Victoria, including community, landholders and Traditional Owner consultations, and ongoing investigations into the corridor and ultimate route. The Draft Corridor Report[59], published 6 October 2023, proposed a narrowed draft corridor for Victoria that is roughly 2 km wide on average. The draft corridor is currently being refined through desktop and field environmental assessments, and discussion with landholders and communities, to arrive at a preferred easement, expected to be publicly available in October 2024. Subject to project assessment and approvals, VNI West is planned for 'first energisation' in late 2028 and fully operational (with inter-network testing complete, subject to market conditions) in Q4 2029.

The scope of VNI West in Victoria and New South Wales consists of:

- Establish Dinawan 500 kV switchyard with two 500/330 kV 1,500 MVA transformers.
- Establish a new terminal station near Kerang with two 500/220 kV 1,000 MVA transformers. This terminal station is labelled as Tragowel in the figure below, however its final name will be confirmed at a later date.
- A new 500 kV double circuit overhead line from a new terminal station at or near Bulgana, to a new terminal station near Kerang, to the Dinawan terminal station in New South Wales, including series capacitive compensation on the line near Kerang to reduce impedance on the new 500 kV network.
- Construction of the Dinawan to Wagga Wagga line as a double circuit 500 kV line, initially operated at 330 kV and later uprate from 330 kV to 500 kV operation (including new 500 kV bays and a transformer station near Wagga Wagga).
- 220 kV connections from the new terminal station near Kerang to the existing 220 kV lines near Kerang.
- Modular power flow controllers or other equipment to prevent overloading on 330 kV lines between Upper/Lower Tumut and South Morang and 220 kV lines between Dederang and Thomastown following certain contingencies.
- 500 kV line shunt reactors at both ends of the three following 500 kV circuits: (i) Bulgana – near Kerang, (ii) near Kerang – Dinawan and (iii) Dinawan – near Wagga Wagga.

[58] See https://aemo.com.au/initiatives/major-programs/vni-west/reports-and-project-updates.

[59] See https://www.transmissionvictoria.com.au/-/media/16bf3d579a8944f084eb37bd800a13a0.ashx.

- Up to +/- 400 MVAr dynamic reactive compensation at the new 220 kV terminal station near Kerang.
- System protection control scheme requirements. AVP is investigating into needs for a new control scheme to prevent system instability and cascade tripping following a non-credible contingency of tripping both 500 kV circuits between BXTS and Dinawan.

Figure 18 Project overview map of VNI West

Control scheme projects in delivery stage

- Keilor Overvoltage Protection Scheme (KOVPS) – with continuous drop in both historical minimum demand and Victorian regional minimum demand forecast, high voltages in areas around Keilor have become a system security concern. See VNPIR sections 2.2 and 2.3 for historical minimum demand conditions and their implications on voltage management across the DSN[60]. This updated control scheme will increase the short-term high voltage limit at KTS 500 kV from 525 kV to 535 kV to address this concern, and is expected to be commissioned in late October 2024.
- Interconnector Emergency Control Scheme (IECS) – a review found insufficient load available for the scheme's load shedding sequences due to reduced loads primarily due to increased distributed PV. The updated scheme includes additional loads and is expected to be commissioned in November 2024.

Projects in neighbouring regions

EnergyConnect

EnergyConnect is a committed interconnector between South Australia and New South Wales, with connection to Victoria at Red Cliffs, with a transfer capacity of 800 MW. The project is aimed at reducing the cost of providing

[60] See https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/nem-forecasting-and-planning/victorian-planning/victorian-annual-planning-report.

secure and reliable electricity across the NEM, while facilitating a longer-term transition to low emission energy sources in Northern South Australia and Southern New South Wales. The completion of EnergyConnect will provide increased transfer capacity between Victoria and New South Wales via the upgraded Red Cliffs to Buronga 220 kV connection. The project is currently in the construction phase.

EnergyConnect will be commissioned in two stages:

- **Stage 1** – a new 275 kV and 330 kV double circuit interconnector is built from Robertstown in mid-north South Australia to Buronga in south-west New South Wales, via a new 275/330 kV substation at Bundey in South Australia. A new 220 kV double circuit line is built between Buronga and Red Cliffs in Victoria, replacing the existing single circuit line, and increasing the line thermal capacity to 800 MVA per circuit. Commissioning of EnergyConnect Stage 1 and inter-network testing is expected to be complete in early 2025. The transfer capacity of the EnergyConnect interconnector (between South Australia and New South Wales) following Stage 1 completion is 150 MW.
  - The Heywood interconnector (HIC) between Victoria and South Australia was upgraded in 2016 with an increased transfer capacity of 650 MW in both directions, however due to stability limits identified following the South Australian system black event in 2016 the interconnector has been limited to 550 MW for South Australian export and 600 MW for South Australian import. Due to an increase in net export to South Australia and to further enable increased imports, following the completion of inter-network testing for EnergyConnect Stage 1, HIC inter-network testing will be carried out and the full capacity of the HIC will be released, expected in mid-2025.
- **Stage 2** – a new 330 kV double circuit transmission line (540 km) will be built between Buronga and Wagga Wagga in New South Wales, a new substation will be constructed at Dinawan in New South Wales, and the existing substation at Wagga Wagga will be upgraded. The section between Dinawan and Wagga Wagga will be constructed to 500 kV but operated initially at 330 kV in anticipation of the VNI West double circuit line connecting at Dinawan at 500 kV. Stage 2 is expected to be completed in mid-late 2027.

This project includes a South Australia Interconnector Trip Remedial Action Scheme (SAIT RAS). The SAIT RAS was designed to cater for the separation of South Australia from 500 kV Victorian network under high power transfer conditions that could result in transient instability in South Australia. This scheme includes a Victorian component to detect any loss of both 500 kV network between Heywood and Moorabool in Victoria, which results in an effective separation of South Australia from South West Victoria, either on a credible contingency or non-credible event. ElectraNet has commissioned stage 1 of the scheme, including its Victorian component delivered by AVP, and is progressing stage 2 of the scheme.

Project Marinus

Project Marinus (previously known as Marinus Link) is a proposed underground and undersea electricity transmission project, comprising two 750 MW high voltage direct current (HVDC) links to further connect Tasmania and Victoria. The project includes new terminal stations and other necessary augmentations in Tasmania and Victoria.

This project will provide the mainland power system with improved access to Tasmania's dispatchable capacity (including deep storages) and high quality VRE opportunities, helping reduce the scale of investment needed on the mainland. The characteristics of customer demand, generation, and storage resources vary significantly between Tasmania and the rest of the NEM, and improved access between Tasmania and the mainland will allow the NEM to capitalise on this diversity[61].

This project will be delivered in two stages, initially as a 750 MW project (Stage 1) with a second 750 MW link to follow at a later date (Stage 2). Project Marinus is proceeding with the early works required to be able to achieve a Final Investment Decision (FID) for Stage 1 by May 2025, enabling commissioning of the first cable in 2030.

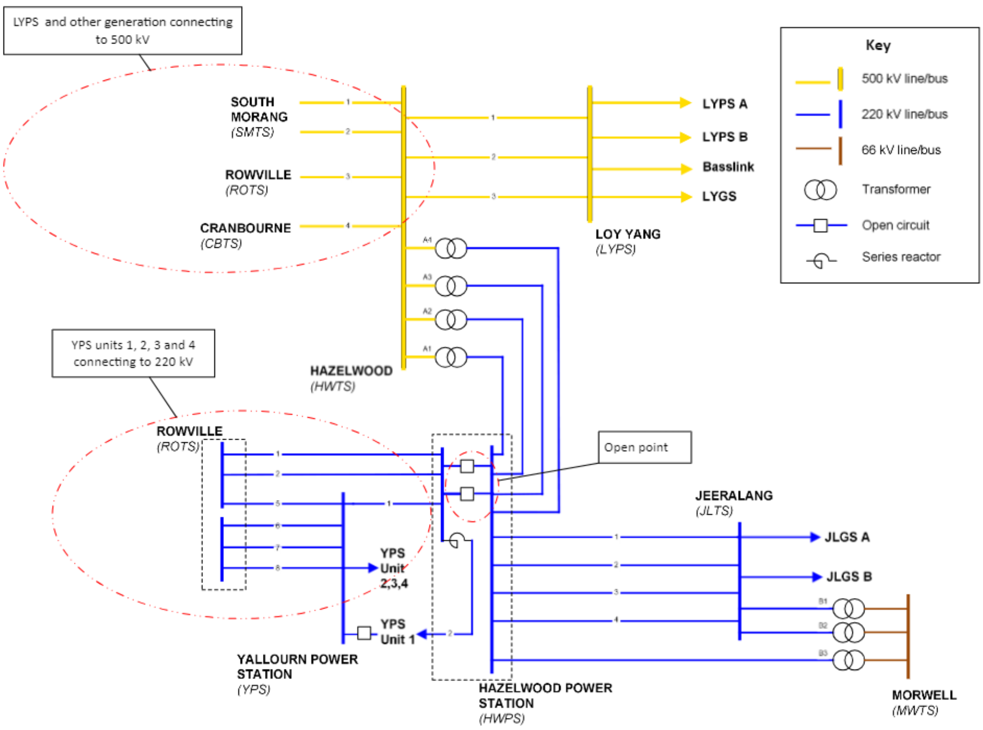
Other planned projects

Reconfiguration of Latrobe Valley 220kV network

The Latrobe Valley reconfiguration project was identified in the 2023 VAPR to enhance the utilisation of 220 kV network between Latrobe Valley and Melbourne and reduce the reliability risks after retirement of Yallourn W Power Station (YWPS). It involves rearrangement of existing infrastructure to minimise risks of overloading transformers and lines at times of high demand post the retirement of YWPS.

At times of high demand while YWPS is in service (**Figure 19**), the 220 kV and 500 kV networks share the supply to Rowville from the Latrobe Valley which minimised risks on the 500/220 kV transformers and on the 220 kV lines connected to Rowville. When YWPS retires, the 220 kV lines from the Latrobe Valley to Rowville become unused, and at times of maximum demand the 500/220 kV A1 transformer at Rowville is forecast to be overloaded under system normal operation if no actions are taken.

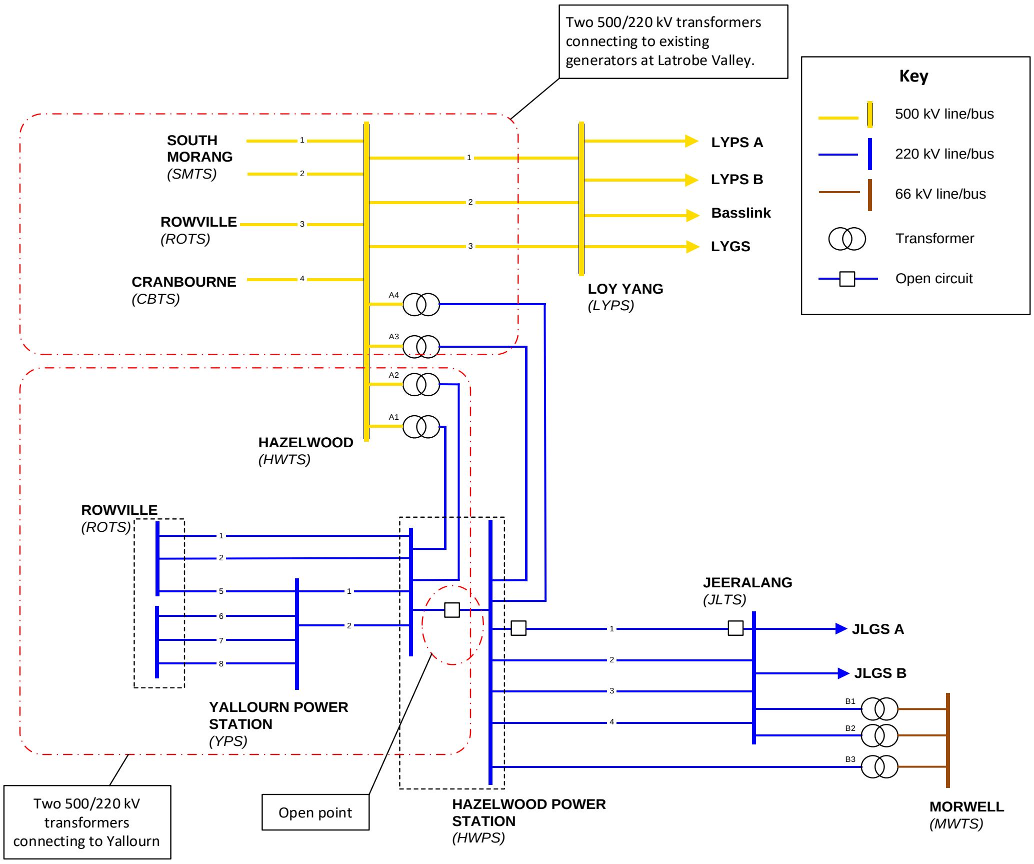
Figure 19 Latrobe Valley high demand radial mode



In the 2023 VAPR, AVP assessed options to reduce the risk on the Rowville A1 transformer after YWPS retires and recommended changing to a modified parallel mode (**Figure 19Figure 20**) as the best option.

[61] See https://aemo.com.au/-/media/files/major-publications/isp/2022/2022-documents/2022-integrated-system-plan-isp.pdf.

Figure 20 Latrobe Valley modified parallel mode



Since the 2023 VAPR, AVP has commenced works with the relevant asset owners to ensure the works will be completed to transition to modified parallel operating mode when YWPS retires. These works include:

Minor works on the Hazelwood – Yallourn #1 and #2 220 kV lines to increase short-term line ratings.

Bypassing the series reactor at Hazelwood 220 kV bus 6.

Switching operations at Hazelwood, Jeeralang and Yallourn to achieve the bus groups shown in **Figure 20**.

Installing inter-trip protection to prevent line overloads on the Hazelwood – Yallourn lines if the parallel line or a Hazelwood 500/220 kV transformer is lost[62]. Initial discussions with the asset owners indicate that this project cost will be below the RIT-T thresholds, therefore a RIT-T will not be undertaken.

Offshore wind transmission project

The Victorian Government has set offshore wind energy generation capacity targets[63] of:

- At least 2 GW by 2032.
- GW by 2035.
- 9 GW by 2040.

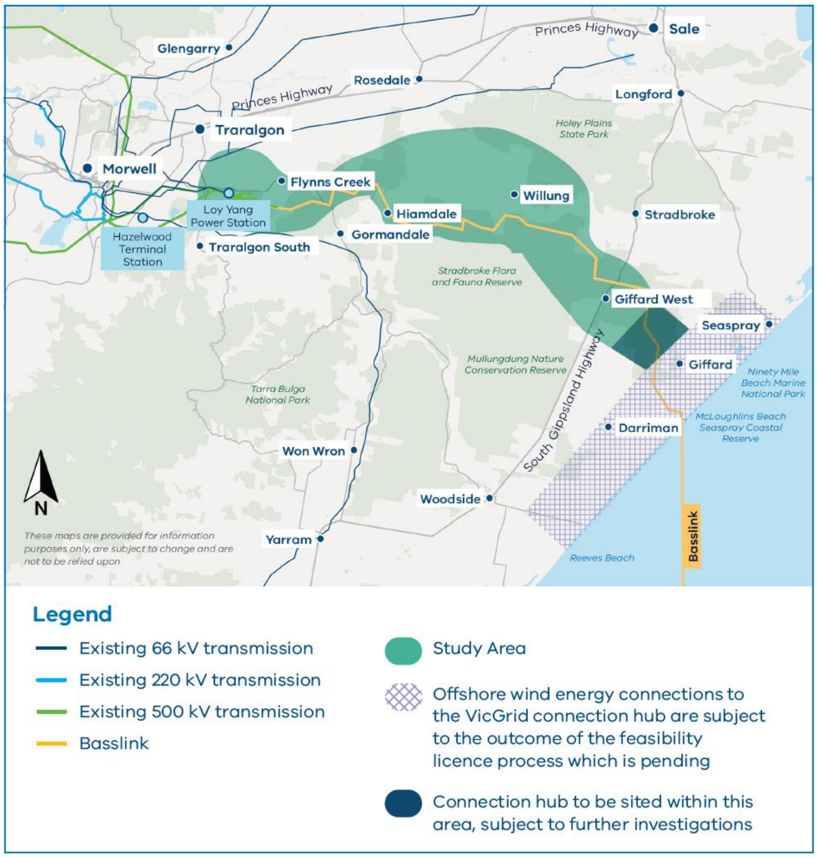
[62] AVP is still evaluating the benefits of a control scheme to address this contingency.

[63] For more information, see https://www.energy.vic.gov.au/renewable-energy/vicgrid/for-businesses-and-developers and https://www.energy.vic.gov.au/renewable-energy/vicgrid/offshore-wind-transmission#heading-2.

VicGrid is leading a coordinated approach and will be the sole developer of the new shared transmission infrastructure for offshore wind generation in the Gippsland and the Southern Ocean REZs.

VicGrid is currently developing declared shared transmission infrastructure from a hub on the Gippsland coast to the 500 kV Loy Yang Power Station Switchyard to facilitate the initial 2 GW target. Community engagement has commenced, and a transmission line study area was released in March 2024.

Figure 21 Study area and indicative connection hub for offshore wind generator connections



Source: https://engage.vic.gov.au/offshore-wind-transmission.

Planned new terminal stations

The following terminal stations are being constructed as part of new connections in the DSN:

- Carwarp TS – a new 220 kV terminal station proposed and currently under construction to connect Carwarp Solar Farm.
- Goorambat East TS – a new 220 kV terminal station proposed to be built to connect Goorambat East Solar Farm.
- Gnarwarre TS – a new 220 kV terminal station proposed to be built to connect Gnarwarre BESS.
- Pine Lodge TS – a new 220 kV terminal station proposed to be built by cutting the 220 kV transmission line between Glenrowan and Shepparton.
- Koorangie TS – a new 220 kV terminal station proposed to be built to connect Koorangie BESS.

3.1.3 Changes to the transmission development plan since last VAPR

The following changes have been made to the Transmission Development Plan since the 2023 VAPR:

- Regulatory investment tests have been initiated for Eastern and Western Metropolitan projects (see Section 3.1.5 for more information).
- A RIT-T for Metropolitan Melbourne Voltage Management has progressed with publication of the PADR on 26 July 2024. The PADR consultation period ended on 6 September 2024 and publication of the PACR is planned for December 2024 (see Section 3.1.5 for details).

3.1.4 Reducing constraints with projects already underway

The on-time delivery of these major augmentation projects is critically important to unlock the network opportunities and enable consumer benefits via renewable energy sources.

Among the top 10 Victorian transmission constraints in 2023-24, eight are from the Western Victoria (V2) and Murray River (V3) REZs. The numbers of top listed constraints from these REZs are consistent with the previous years. Furthermore, on average, 16.7% and 3.1% of curtailment in VRE generation was observed in Murray River (V2) and Western Victoria (V3) REZs throughout 2023-24, which closely lines up with these highest binding constraints. Many of the constraints listed are expected to be reduced by the completion of major augmentation projects such as WRL and VNI West, with these two projects expected to reduce the impact of seven out of 10 of the constraints listed.

The tables below summarise existing Victorian transmission network constraints where there are projects underway that are expected to reduce the impact of those constraints. The constraints are ranked by their impact on generation dispatch during 2023-24. Where there are currently no planned projects, AVP will continue to monitor the network constraints and raise suitable projects when options with positive net market benefits are identified. Limitations where AVP currently has no planned projects have not been included below but are in the *Victorian Network Performance and Insights Report*[64].

Table 7 contains the existing constraints in the Western Victoria and Murray River REZs which are the areas where dispatch was constrained the most during 2023-24 and the impact of the planned projects on these constraints. **Table 8** contains the existing constraints in the South Western Victoria REZ and the impact of planned and ongoing projects on these constraints. **Table 9** contains the remaining constrained areas of Eastern Victoria, the New South Wales/Victoria interconnector, and the Latrobe Valley and impact of planned projects on them.

[64] See the *Victorian Network Performance and Insights Report*, at https://aemo.com.au/energy-systems/electricity/national-electricity-market-nem/nem-forecasting-and-planning/victorian-planning/victorian-annual-planning-report.

Table 7 Impact of planned projects on existing limitations – Western Victoria and Murray River REZs

Rank	Equation(s)	Description of constraint	Upcoming projects	Expected completion date
1	North-west Victoria voltage oscillations (prior outage)	This represents a set of the network constraint equations associated with voltage oscillation during a range of prior outage conditions. More outages have occurred in 2023-24 compared to 2022-23 and, due to this, these constraints have bound more. AEMO is continuously reviewing these constraints as revised models are obtained and based on upcoming outage schedule.	System strengthening projects being delivered as a part of the Victorian Government's RDP are expected to reduce the impact of this constraint.	FY 2025-26
2	Kerang voltage collapse V^^V_NIL_KGTS V^^V_NIL_KGTS_2	To avoid voltage collapse at Kerang due to the loss of Horsham – Murra Warra – Kiamal 220 kV line considering Murraylink Very Fast Run Back (VFRB) scheme disabled.	EnergyConnect and the connection of Koorangie Energy Storage System are expected to reduce the impact of these constraints.	FY 2027-28
3	Wemen to Kerang voltage collapse V^^V_MLNK_KGTS	To avoid voltage collapse at Kerang due to the loss of Horsham – Murra Warra – Kiamal 220 kV line during an outage of Murraylink.	Connection of Koorangie Energy Storage System is expected to reduce the impact of this constraint.	FY 2025-26
4	Waubra to Ballarat thermal V>>NIL_WBBA_RCWEKG, V>>NIL_WBBA_KGBE, V>NIL_WBBA_KMRC, V>>NIL_WBBA_RCBSS	To avoid overloading Waubra to Ballarat 220 kV line on trip of the Red Cliffs – Wemen – Kerang 220 kV line or Kiamal to Red Cliffs 220 kV line or Kerang to Bendigo 220 kV line or Red Cliffs to Buronga 220 kV line.	Minor augmentations as part of the Victorian Government's RDP Stage 1 projects and the WRL project increase the thermal capability of the Ballarat – Waubra – Ararat – Crowlands – Bulgana – Horsham – Murra Warra – Kiamal 220 kV corridor to reduce the impact of this limitation.	FY 2027-28
5	Red Cliffs voltage collapse V^^SML_NIL_3 V^^SML_NSWRB_2	To avoid voltage collapse at Red Cliffs for the loss of Bendigo to Kerang 220 kV, Darlington Point to Balranald (X5) or Balranald to Buronga (X3) 220 kV lines when the New South Wales Murraylink runback scheme is unavailable.	EnergyConnect and the connection of Koorangie Energy Storage System are expected to reduce the impact of these constraints.	FY 2027-28
7	Ararat to Waubra thermal V>>NIL_ARWB_RCWEKG, V>>NIL_ARWB_KGBE	To avoid overloading Ararat to Waubra 220 kV line due to the loss of 220 kV lines at either Kerang to Bendigo, or Red Cliffs to Wemen to Kerang.	Following an RDP Stage 1 project milestone, the static ratings at Ararat have already been upgraded in August 2023. As the previous static ratings at Ararat have been the primary driver of this constraint, this constraint has already been improved compared to 2022-23. The impact of this limitation is expected to be further reduced after the completion of the WRL project.	FY 2027-28
9	Red Cliffs voltage collapse V^SML_HORC_3, V^SML_KGRC_3	These are the outage constraints to avoid voltage collapse at Red Cliffs. Outages are of Horsham to Red Cliffs through Murra Warra 220 kV, Kerang to Red Cliffs through Wemen 220 kV, Ararat to Waubra 220 kV lines.	EnergyConnect is expected to reduce the impact of these constraints.	FY 2027-28

Rank	Equation(s)	Description of constraint	Upcoming projects	Expected completion date
	V^^SML_ARWBBA_1 V^SML_BUDP_3	V^SML_BUDP_3 is to avoid voltage collapse for loss of Bendigo to Kerang 220 kV line. This is also an outage constraint at the time of Buronga to Balranald (X3) or Balranald to Darlington Pt (X5) outage.		
11	Ballarat to Bendigo thermal V>>NIL_BABE_HOMRKM, V>>NIL_BABE_KMRC	To avoid overloading Ballarat to Bendigo for loss of Horsham – Murra Warra – Kiamal 220 kV or Kiamal to Red Cliffs 220 kV lines.	WRL and VNI West are expected to reduce the impact of these constraints.	FY 2029-30

Table 8 Impact of planned projects on existing limitations – south-west corridor

Rank	Equation	Description	Upcoming projects	Anticipated completion date
13	Haunted Gully to Moorabool And Mortlake to Moorabool Voltage collapse V^^V_NIL_SWVIC	To manage flow towards Moorabool across Haunted Gully to Moorabool and Mortlake to Moorabool 500 kV lines due to the loss of Haunted Gully to Moorabool 500 kV line and both Alcoa Portland (APD) potlines.	Mortlake Power Station (MOPS) turn-in project, as a part of the Victorian Government's RDP and the new terminal station at Cressy, will reduce the impact of this constraint	FY 2025-26
14	Elaine to Moorabool thermal V>>NIL_ELML_BAML2	To avoid overloading Elaine to Moorabool 220 kV line on trip of Ballarat to Moorabool No. 2 220 kV line.	The WRL project will reduce the impact of this constraint.	FY 2027-28
21	Moorabool to Geelong thermal V>>XGTML2_KTTX2_1_R2	This is a multiple outage thermal constraint. Outages are of Geelong to Moorabool No. 2 220 kV line and Keilor A2 500/220 kV transformer. This constraint is formulated to avoid overloading on the remaining Moorabool to Geelong 220 kV line on trip of Sydenham to Keilor 500 kV line.	The Western Metro Reinforcement project is expected to reduce the impact of this constraint.	RIT-T in progress, refer to Section 3.1.5

Table 9 Impact of planned projects on existing limitations – Eastern Victoria, Victoria – New South Wales Interconnector and Latrobe Valley

Rank	Equation	Description	Upcoming projects	Anticipated completion date
6	VNI export voltage collapse during outages V^^N_xxx	Avoid voltage collapse around Murray for loss of all APD potlines during planned transmission equipment outages. These constraints each behave similarly to their system normal counterpart V^^N_NIL_1.	As the VNI East upgrade project has been completed, both market impact and binding hours have been reduced. VNI West is expected to further reduce the impact of this constraint.	FY 2029-30

Rank	Equation	Description	Upcoming projects	Anticipated completion date
		These constraints are invoked during outages of any line in, or connecting to, the 330 kV corridor between Victorian and New South Wales capital city load centres. Outages of other significant lines including 500 kV Latrobe Valley lines in Victoria and 220 kV lines in Southwest New South Wales also may require such constraints to be invoked.		
8	VNI voltage collapse V^^N_NIL_1	To avoid voltage collapse in northern Victoria and southern New South Wales for loss of APD potlines following fault on one of the 500 kV lines in Southwest Victoria.	VNI West is expected to further reduce the impact of this constraint.	FY 2029-30
18	VNI export transient stability during outages V::N_xxx	Prevent transient instability for fault and trip of Hazelwood to South Morang line during planned transmission equipment outages.	The market impact of this constraint was mainly driven by outages of the Dederang to South Morang 330 kV lines and South Morang series capacitors in 2022. Both market impact and binding hours are reduced significantly in 2023-24 due to the recent upgrade and transformer installation. VNI West is expected to further reduce the impact of this constraint.	FY 2029-30

3.1.5 Ongoing regulatory tests for future developments

What is a regulatory investment test?

Purpose of a RIT-T

Strategic planning of the power system is crucial to making informed decisions in the long-term interests of Australian energy consumers. Under the National Electricity Law, AVP is responsible for planning and directing augmentation for the Victorian electricity transmission DSN.

The RIT-T process is a regulatory mechanism under the NER that applies an economic cost-benefit test on proposed investments for the shared transmission network of the NEM. It is designed to identify the most economically efficient investment to all those that produce, consume or transport electricity in the NEM, including for changes in Australia's greenhouse gas emissions whether or not the net benefit of changes in emissions is to those that produce, consume or transport electricity in the NEM.

As the RIT-T proponent, AVP follows one of two RIT-T processes outlined in the NER, depending on the nature of the investment. Where the investment is not an Actionable ISP Project the process of NER 5.16 applies, and for an ISP Actionable Project the RIT-T process of NER 5.16A applies.

Stages involved in a RIT-T

The RIT-T process generally has three stages and requires transmission network planners considering significant investment for the transmission network to publish a report at each stage:

- **Project Specification Consultation Report (PSCR)** – the first report seeks feedback and advice on the identified need for investment as well as credible options that look at both network and non-network solutions to address the identified need. The consultation period for the PSCR is a minimum of 12 weeks from the publication date of the PSCR. Where a proposed investment is an Actionable ISP project, the PSCR stage is not required, as consultation is managed through the ISP publication.
- **Project Assessment Draft Report (PADR)** – the second report of the process considers feedback on the PSCR and identifies and seeks feedback on the proposed preferred option and assessment methodology. The PADR must be published within 12 months of the end of the consultation period for the corresponding PSCR, unless an extension is requested and granted by the Australian Energy Regulator (AER). The consultation period must not be less than six weeks from the publication date of the PADR.
- **Project Assessment Conclusions Report (PACR)** – the final report of the RIT-T considers feedback on the PADR and presents the transmission planner's recommended solution (preferred option) to deliver the highest net economic benefit and intended course of action. The PACR must be published as soon as practical after the end date of the consultation period for the corresponding PADR.

The end-to-end timing for undertaking a RIT-T can vary significantly depending on the complexity of potential credible options and the drivers of the identified need, but typically takes between 12 and 18 months from publication of the PSCR to completion of the PACR.

AVP is currently working on the RIT-Ts outlined in the sections below.

Metropolitan Melbourne Voltage Management RIT-T

Investment is required to maintain Victorian DSN voltages in the metropolitan Melbourne region within operational and design limits, during both maximum and minimum demand periods, in a more efficient and cost-effective manner. This investment need is driven by a progressive increase in maximum demand, a progressive decrease in minimum demand, the retirement of end-of-life reactive power assets (capacitor retirements as detailed in Section 4.6.2), and the withdrawal of coal-fired generation.

In July 2024, AVP published the Metropolitan Melbourne Voltage Management RIT-T PADR[65]. Developing the PADR included reassessing the identified need presented in the PSCR, due to project status changes with some previously proposed connections progressing to committed status, an assessment of each credible options' benefits and the methodology used to assess the option costs and benefits. The PADR presented the proposed preferred option, which is to progressively install, and contract services from, reactive power assets, including:

- Three 100 MVAr shunt reactors on the 220 kV level, one each at South Morang, Thomastown, and West Melbourne terminal stations, to be in service by 2029.
- One 100 MVAr shunt capacitor on the 220 kV level at Deer Park TS, to be in service by 2031.
- Two 100 MVAr shunt capacitors on the 220 kV level, one each at Malvern and Tyabb terminal stations, to be in service by 2034.

The proposed investments have a total estimated capital cost of $45.6 million (in present value terms) and are forecast to deliver a net present value (NPV) economic benefit of approximately $256.4 million.

Following consideration of submissions received as part of the PADR consultation, which closed on 6 September 2024, a PACR will be prepared in accordance with NER 5.16.4 and is planned to be published by Q4 2024.

Victorian System Strength Requirement RIT-T

Under the new system strength framework which came into effect on 2 December 2022, AVP is responsible for proactive provision of system strength services, as the System Strength Service Provider (SSSP) for Victoria, to maintain power system stability and to facilitate efficient generator and storage connections as set out in the 10-year forecast provided in the most recent System Strength Report[66].

The System Strength RIT-T is a reliability corrective action RIT-T aimed at identifying the most economically efficient options portfolio, considering both network and non-network options, to meet the system strength requirements. This requirement is broken into the minimum and efficient system strength requirements, both of which AVP is required to procure services for.

In July 2023 AVP published the PSCR for the System Strength RIT-T, which summarised both the minimum fault level requirement and the IBR forecast required to be met under the efficient system strength requirements that AEMO set in its 2022 System Strength Report. The PSCR quantified the potential network solutions to meet these forecasts.

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[65] AEMO, Metropolitan Melbourne Voltage Management RIT-T, at https://aemo.com.au/initiatives/major-programs/metropolitan-melbourne-voltage-management-regulatory-investment-test-for-transmission.

[66] At https://aemo.com.au/energy-systems/electricity/national-electricity-market-nem/nem-forecasting-and-planning/system-security-planning.

In aggregate, meeting the forecasts of the 2022 System Strength Report was estimated to require a system strength contribution, which could be from a variety of sources, the equivalent of nine 250 MVA synchronous condensers and one 125 MVA synchronous condenser across three of the five Victorian system strength nodes, where a 250 MVA synchronous condenser was assumed to contribute 1,100 MVA of available fault level. Since publication of the PSCR and the 2023 VAPR, AEMO National Planning published its 2023 System Strength Report, which reconfirmed the minimum system strength requirements set in the 2022 report but amended, and significantly increased, the efficient level of system strength requirements based on the updated forecast of IBR connections under the 2024 ISP *Step Change* scenario. For Victoria, the increase in forecast IBR is heavily impacted by an increase in offshore wind forecast in the 2024 ISP *Step Change* scenario following the Victorian Government legislating its offshore wind targets.

AVP will need to procure sufficient system strength services to meet both the minimum three-phase fault level requirement and the IBR forecast set in the 2023 System Strength Report, as shown in **Table 10** and **Table 11** respectively.

Table 10 Victorian minimum three phase fault level requirement (MVA)

System strength node and voltage	Pre-contingency fault level requirement (MVA)	Post-contingency fault level requirement (MVA)
Dederang 220 kV	3,500	3,300
Hazelwood 500 kV	7,700	7,150
Moorabool 220 kV	4,600	4,050
Red Cliffs 220 kV	1,786	1,036
Thomastown 220 kV	4,700	4,500

Note: as specified in Table 49, AEMO, 2023 System Strength Report, at https://aemo.com.au/-/media/files/electricity/nem/security_and_reliability/system-strength-requirements/2023-system-strength-report.pdf.

Table 11 AEMO 2023 System Strength Report – forecast IBR generation (MW)

System strength node	2025	2026	2027	2028	2029	2030	2031	2032	2033
Moorabool	605	1,530	2,004	2,704	3,012	3,012	3,012	3,702	3,873
Hazelwood	77	243	1,251	1,251	2,459	2,629	3,781	4,932	5,617
Dederang	313	313	313	313	313	313	313	313	313
Red Cliffs	365	665	665	665	665	743	743	743	968
Thomastown	200	200	200	200	200	236	389	540	557

Note: as specified in tables 53, 55, 57, 59 and 61, AEMO, 2023 System Strength Report, at https://aemo.com.au/-/media/files/electricity/nem/security_and_reliability/system-strength-requirements/2023-system-strength-report.pdf.

The change in forecast IBR presented in the 2023 System Strength Report has increased the overall system strength services required to meet the standard by approximately 3,300 MVA (or 25 percent). It should be noted that the minimum level, which is approximately half the total requirement, must be provided by services capable of providing protection-quality fault current and could include new synchronous condensers, service contracts with existing thermal or hydro units, new gas turbine units fitted with clutches, or the retrofit of existing generators as they retire from the energy market. The remaining requirement beyond the minimum level can be met by a variety of existing and new technologies with the ability to stabilise local voltages, including grid-forming inverters. The timing, location and quantity of the services required to meet the standard are detailed in Section 4.

In addition to considering the impact of updated IBR forecasts on the system strength need, AVP has also continued progressing development of the System Strength RIT-T PADR. A high-level overview of the PADR development process includes:

- Identifying a preliminary portfolio of options, comprising both network and non-network solutions.
- Assessing the viability of different technologies to meet different parts of the system strength requirement.
- Engineering studies to validate the technical feasibility of option portfolios and their ability to meet the identified need.
- Market modelling to assess the changes in dispatch of synchronous generators to meet system strength requirements by evaluating the benefits to the market.
- Cost benefit analysis to estimate the net market benefits and rank the feasible options to determine the option that maximises the net economic benefit.

The System Strength PADR is expected to be published in April 2025.

Eastern Victorian Grid reinforcement RIT-T

Significant changes in the eastern metropolitan Melbourne network are starting to occur and are anticipated to continue over the next decade. These changes include the retirement of YWPS in 2028 and forecast demand growth projected to exceed the capacity of the eastern metropolitan network. The Latrobe Valley reconfiguration project (see Section 3.1.2) will ensure the 220 kV lines from the Latrobe Valley to Rowville remain fully utilised post-retirement of YWPS. However, due to the forecast demand growth in the eastern metropolitan area, additional investment is required to address the following limitations identified in the 2023 VAPR:

- Thermal overloading of Thomastown – Ringwood 220 kV line for loss of the Rowville A1 transformer.
- Thermal overloading of the Rowville A1 500/220 kV transformer during system normal.

Pre-feasibility studies have been conducted since the publication of the 2023 VAPR, to quantify the identified need and gauge the order of benefits associated with potential credible options. These studies indicated that additional investment in the eastern metropolitan area to address thermal limitations resulting from forecast demand growth is likely to deliver positive net market benefits, thereby warranting a RIT-T.

AVP is expecting to publish the first publication of the RIT-T, the PSCR, for this project in Q4 2024, outlining credible network options and technical characteristics required from non-network options to meet the identified need, being to support the forecast demand growth in the eastern metropolitan area. Network options that are being considered for the PSCR include, but are not limited to:

- Bringing forward already planned VNI West works to on Eildon – Thomastown 220 kV to address the forecast line overloads.
- Cutting the existing lines between Rowville and Thomastown into Ringwood and Templestowe and then operating the lines between Ringwood and Templestowe as normally open (to reduce fault levels).
- Installing a third 500/220 kV transformer at Rowville to provide backup to the existing No. 1 500/220 kV transformer providing supply to the Rowville No. 3-4 220 kV Bus Group.

- Installing a second 500/220 kV transformer at Cranbourne to provide backup to the existing transformer and provide supply to the Rowville No. 1-2 220 kV Bus Group and transferring the Rowville No. 2 500/220 kV transformer to the Rowville No. 3-4 220 kV Bus Group to back up the No. 1 500/220 kV transformer.

Western Metropolitan Melbourne reinforcement RIT-T

The 2023 VAPR highlighted that, at times of high demand in the western metropolitan area and high wind generation in and around the Western and South West Victoria REZs, the 220 kV transmission corridor between Moorabool, Geelong, Deer Park, and Keilor is becoming constrained and is anticipated to become heavily constrained over the coming decade. The main driver of this limitation is growing contribution of wind generation meeting peak demand, coupled with forecast demand growth in the Geelong and Deer Park areas. This is leading to an inability to supply loads to the western metropolitan Melbourne load centres in Geelong and Deer Park due the thermal capacity limitations in the Moorabool – Geelong – Deer Park – Keilor 220 kV corridor during contingent conditions.

Since publishing the 2023 VAPR, AVP undertook pre-feasibility studies to assess and quantify the identified need and gauge the order of benefits associated with potential credible options. These studies indicated that additional investment in the western metropolitan area is likely to deliver positive net market benefits, thereby warranting a RIT-T.

AVP has commenced development of the Western Metropolitan Melbourne Reinforcement RIT-T and plans to publish the PSCR by Q4 2024. The PSCR will quantify the identified need, outline the credible options to be considered in the RIT-T and summarise the technical characteristics required of a non-network option to meet the identified need. Network options that are being considered for the PSCR include, but are not limited to:

- Cut Geelong – Keilor #1 and #3 220 kV lines into Deer Park and decouple Deer Park from Keilor or Geelong.
- Perform works to increase line rating of existing Geelong – Moorabool 220 kV lines (replace limiting plant and install wind monitoring).
- Construct a third Geelong – Moorabool 220 kV line.
- Construct new 500/220 kV Truganina terminal station cutting into the existing Moorabool – Sydenham 500 kV lines and build 220 kV lines from Truganina to Deer Park.

4 Future outlook of the DSN

This section presents the outcome of the 2024 Annual Planning Review undertaken by AVP to assess network capability and identify potential new limitations that may impact supply reliability or reduce system performance for the next 10 years.

This section also provides information on other planning activities – such as system security, review of existing and proposed control schemes for the DSN, and Joint Planning with DTSOs and NSPs – undertaken by AVP as the jurisdictional planner for Victorian DSN.

Key outcomes of the Annual Planning Review

Projected network limitations:

- Key outcomes of the past three VAPRs consistently demonstrate emerging network limitations and urgency of the delivery of identified augmentation projects.
- The 2024 VAPR concludes network limitations are largely consistent with those reported in 2023 VAPR, except two new priority limitations which are mainly driven by the changing supply mix in Victoria:
  - Increased import from New South Wales at times of peak demand is driving a thermal limitation on the Eildon – Thomastown 220 kV line when the Rowville A1 500/220kV transformer is lost under contingency. It is anticipated that the RIT-T for the eastern metropolitan area will resolve this limitation as it is already responding to other Rowville A1 transformer contingencies.
  - Increased import from New South Wales at times of peak demand is driving a thermal limitation on the Red Cliffs – Wemen – Kerang 220 kV line. Network investment is likely to be required in the next decade to address this limitation.

Asset replacements:

- AusNet Services' 2024 asset replacement and refurbishment plans are largely consistent with those presented in the 2023 VAPR.
- AVP continues timely and effective joint planning with AusNet Services to assess and identify the optimal solutions to key replacement projects including (but not limited to):
  - South Morang Terminal Station 500/330 kV and 330/220 kV transformers.
  - Keilor 500/220 kV transformers.
  - Gas Insulated Lines (GIL) at Rowville Terminal Station.
  - Moorabool Terminal Station A1 500/220 kV Transformer and 220 kV Shunt Reactor.

- AVP continues to work with other DTSOs and distribution businesses (DBs) to identify credible and cost-effective solutions to the emerging challenges caused by increased fault levels across the DSN, due to the growing generation portfolio, and managing system security at times of low demand.

System security planning activities:

- In the 2023 NSCAS Report[67], AEMO declared a Reliability and Security Ancillary Services (RSAS) gap for thermal overloading and voltage control following credible contingences on the 220 kV network near Deer Park TS. AVP has taken the following actions:
  - Commenced the Western Metro Melbourne reinforcement RIT-T to address the thermal overloading and associated reliability risks (see Section 3.1.2).
  - Addressed the voltage management needs through the Metropolitan Melbourne Voltage Management RIT-T, for which the PACR is planned for publication by Q4 2024 (see Section 3.1.5).
- No inertia shortfall was declared in the 2023 Inertia Report[68] for Victoria due to the number of interconnectors joining Victoria and neighbouring regions.
- No inertia shortfall for the sub-region of Victoria and South Australia has been declared. A previous shortfall, starting from July 2026, that was identified in the 2022 Inertia Report, has been removed due to the expected delivery of Humelink.

4.1 Annual Planning Review methodology

The VAPR identifies opportunities to address transmission network limitations emerging over the next 10 years, where credible solutions are likely to deliver positive net market benefits. The overall planning approach is described in Appendix A1[69] and the identified limitations are discussed in the following sections.

4.1.1 Categorisation of limitations

For each network element, screening studies are typically undertaken for a base case and a worst case scenario, to capture a wide range of limitations. The worst case scenario differs, depending on the transmission network element under consideration, and is a variation on the base case scenario designed to test that specific network element. For example, in a particular location the worst case scenario may be 100% VRE output, while in another the worst case may be 0% VRE.

AVP identifies credible options to address the identified limitations and estimates the costs of the options. Options are then assessed to determine if they are likely to deliver positive net market benefits (where applicable). Based on these assessments, the limitations are categorised as shown in **Figure 22** and described below.

[67] See https://aemo.com.au/-/media/files/electricity/nem/security_and_reliability/system-strength-requirements/2023-nscas-report.pdf.

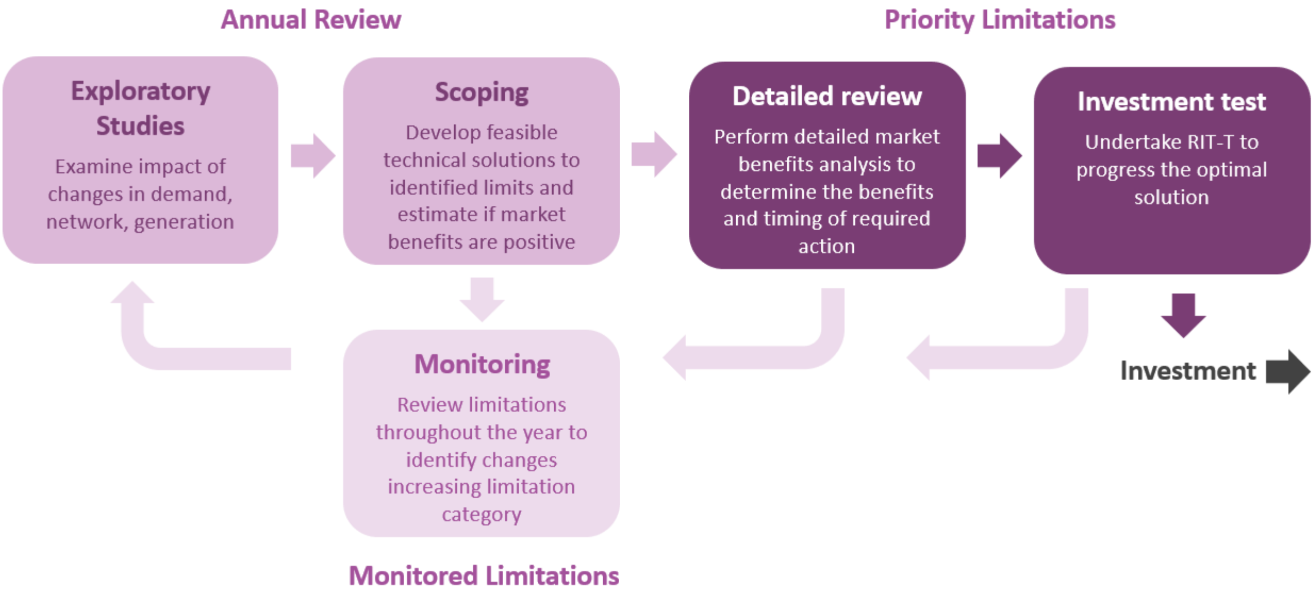
[68] See https://aemo.com.au/-/media/files/electricity/nem/security_and_reliability/system-strength-requirements/2023-inertia-report.pdf.

[69] Further information can be found at https://www.aemo.com.au/-/media/Files/Electricity/NEM/Planning_and_Forecasting/Victorian_Transmission/2016/Victorian-Electricity-Planning-Approach.pdf.

In 2024, AVP updated the categories of limitations that are identified to streamline the activities that are undertaken when limitations are identified. In 2023 there were four categories of limitations – emerging, priority, developing and monitored. This has now been reduced to priority and monitored limitations as defined below:

- **Priority limitations** – AVP will commence detailed analysis on options to alleviate this limitation[70]. Priority limitations have credible options that are anticipated to deliver positive net market benefits.
- **Monitored limitations** – AVP will continue to monitor this limitation, and either reassess it as part of the next APR or commence detailed analysis if triggered by a new market development.

Figure 22 Identification of network limitations – the planning cycle



AVP performs high-level economic assessments in determining priority limitations. This analysis and categorisation can provide signals for potential non-network development opportunities, such as localised generation or demand response. Priority limitations may also include limitations needing reliability corrective actions where credible solutions are not required to deliver positive net market benefits.

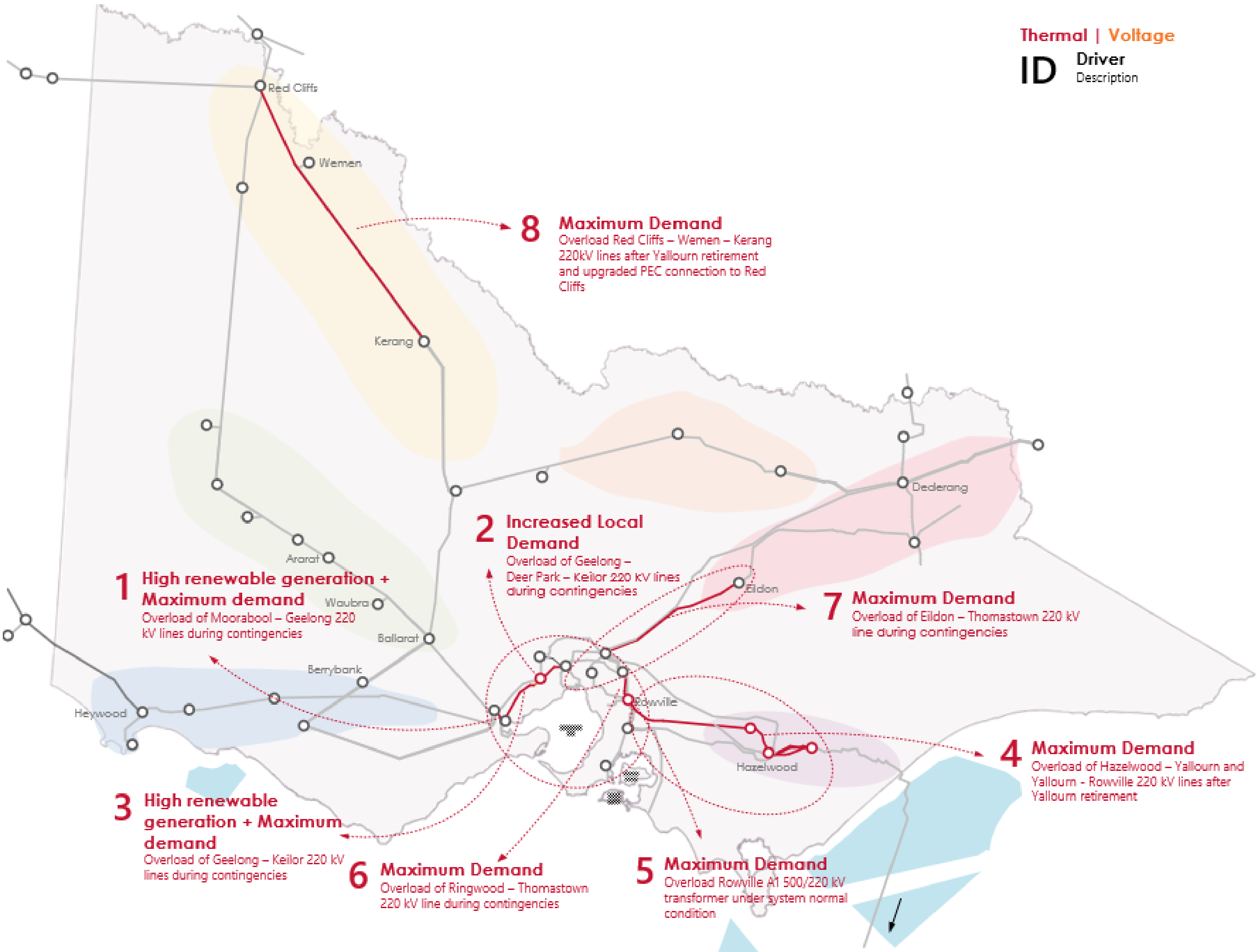
AVP undertakes joint planning with AEMO in its function as National Transmission Planner under the National Electricity Rules (NER) (ISP and System Security Planning process), other TNSPs and Victorian DNSPs to address transmission limitations, challenges, and opportunities. Victorian joint planning outcomes have been incorporated into the limitation summaries presented in this section.

Figure 23shows the limitations under investigation in this Annual Planning Review, assuming the network developments already progressing and discussed in Section 2 proceed. A complete list of the limitations (both priority and monitored) is provided in Appendix A2. Appendix A1 has more information on AVP's approach to transmission network limitation reviews.

[70] All existing developing, emerging and priority limitations from the 2023 APR have been migrated to priority limitations in the 2024 APR.

Note that the numbering of the limitations in this section does not reflect the ranking of most significant Victorian transmission constraints observed in 2023-24. They relate to future limitations that are forecast over the next decade that may justify network augmentation.

Figure 23 Priority limitations under investigation



4.2 Projection of network limitations in the planning horizon

4.2.1 Priority limitations identified in the 2023 VAPR

The 2023 VAPR identified six *priority limitations* for which AVP commenced feasibility studies and regulatory investment tests. **Table 12** summarises progress made by AVP on these limitations, with further details in Section 3 of this report[71].

[71] All existing developing, emerging and priority limitations from the 2023 APR have been reclassified as priority limitations in the 2024 APR.

Table 12 Priority limitations from 2023 VAPR

#	Limitation (estimated constraint date)	Description	Status/next steps
1	**Thermal capacity limitation – Overloading of the Moorabool – Geelong 220 kV lines for trip of the parallel line (existing)**	This limitation is due to commitment of additional renewable generation and storage capacity in South West Victoria (V4), coupled with higher demand growth in the metropolitan area and generation retirement in Latrobe Valley.	AVP has commenced the Western Metro RIT-T to provide a holistic solution that will address limitations #1, #2 and #3. More detail about the options considered in the RIT-T is in Section 3.1.53.1.5.
2	**Thermal capacity limitation – Overloading of the Geelong – Deer Park line for trip of the Deer Park – Keilor line, or the Deer Park – Keilor 220 kV line for trip of the Geelong – Deer Park line (existing)**	These limitations are due to demand growth in the western metropolitan area supplied from Geelong, Deer Park and Keilor terminal stations.	
3	**Thermal capacity limitation – overloading Geelong – Keilor 220 kV lines for post credible contingencies (existing)**		
4	**Thermal capacity limitations - Transfer capacity from Latrobe Valley to Melbourne post Yallourn retirement (July 2029)**	This limitation is primarily due to changing flow sharing of the 500 kV and 220 kV networks from the Latrobe Valley to metropolitan Melbourne following retirement of YWPS.	AVP has identified a new switching arrangement at Hazelwood PS 220 kV (the modified parallel mode), for post-YWPS retirement to utilise the eastern 220 kV corridor. Changing the Latrobe Valley configuration to modified parallel mode significantly reduces the short-term risks in supplying metropolitan Melbourne. More detail about this solution is in Section 3.1.2.
5	**Thermal capacity limitation – Overloading of the Rowville A1 500/220 kV transformer during system normal (July 2029)**	This limitation is primarily due to higher demand growth in the Melbourne metropolitan area, which is further exacerbated by retirement of YWPS.	AVP has commenced the Eastern Metro Grid Reinforcement RIT-T to provide a holistic solution that will address these limitations as well as limitation #7 (Eildon – Thomastown thermal limitation). This project is to address the residual risk that exists after modified parallel mode discussed in limitation #4 is implemented. More detail about the options considered in the RIT-T is in Section 3.1.53.1.5.
6	**Thermal capacity limitation – Overloading of Thomastown – Ringwood 220 kV line for loss of the Rowville A1 transformer (July 2029)**		

4.2.2 New priority limitations from 2024 VAPR

AVP's 2024 Annual Planning Review identified two new priority limitations in the DSN as listed in **Table 13**. These limitations were classified as monitored limitations in the 2023 VAPR and in previous years. Due to the increased demand forecast over the next five years of the planning horizon, together with the changes in the power flow paths due to network changes, the impact of these limitations has elevated them into priority limitations.

Table 13 New priority limitations from 2024 VAPR

#	Limitation (estimated constraint date)	Description	Status/Next steps
7	**Thermal capacity limitation – Overloading of Eildon – Thomastown 220 kV line for trip of Rowville A1 transformer (December 2025)**	This limitation is caused by the increased demand growth in the Melbourne metropolitan area, which is further exacerbated by changes in how power flows around the network following retirement of Yallourn W Power Station. These changes tend to increase VNI	AVP has commenced the RIT-T process for the Eastern Metro Grid Reinforcement RIT-T to provide a holistic solution that will address this limitation in addition to the limitations #5 (Rowville A1 transformer thermal limitation) and #6 (Ringwood – Thomastown line thermal limitation).

#	Limitation (estimated constraint date)	Description	Status/Next steps
		import into Victoria, and thus flow on the Eildon – Thomastown 220 kV line.	More detail about the options considered in the RIT-T is in Section 3.1.53.1.5.
8	**Thermal capacity limitation – Overloading of the Red Cliffs – Wemen – Kerang corridor during periods of high demand (December 2028)**	This limitation is elevated primarily due to expected increase in power transfer from New South Wales into Victoria via the upgraded 220 kV network between Buronga and Red Cliffs interconnector at times of maximum demand following completion of the EnergyConnect project. The retirement of YWPS could also increase the need for more import from New South Wales in general.	AVP will commence pre-feasibility studies to assess the limitation and identify credible options to address it. AVP may initiate a RIT-T for this limitation prior to the 2025 VAPR.

Eildon – Thomastown 220 kV line thermal limitation (limitation #7)

Thermal loading on the Eildon – Thomastown 220 kV line was identified as a monitored limitation in the 2023 VAPR and has been elevated to a priority limitation in the 2024 VAPR due to the impact of the latest demand forecast. The primary driver of this limitation is increasing demand in the eastern metropolitan area, specifically supplied at Ringwood, Templestowe, and Thomastown terminal stations. It was observed that VNI West reduces the scale of this risk, however it is not able to completely alleviate this limitation.

During peak demand times from summer 2026-27, the loading of Eildon – Thomastown 220 kV lines is forecast to exceed its short-term rating for a contingent trip of Rowville A1 500/220 kV transformer (see **Figure 24**).

Figure 24 Possible overloading of Eildon – Thomastown 220 kV line under contingencies

A holistic approach is required to address this limitation, as solutions for the system normal overload of the Rowville A1 transformer (limitation #5) and the contingent loss of Rowville A1 transformer impacting Ringwood –

Thomastown 220 kV line (limitation #6) will impact on the contingency overloading of the Eildon – Thomastown 220 kV line.

To address limitations beyond retirement of YWPS, AVP has commenced the RIT-T for the eastern metropolitan area to provide a long-term holistic solution to all the limitations in the area. AVP has identified that the solutions proposed in the Eastern Metro RIT-T will also alleviate this limitation. These options include:

- Installing a third 500/220 kV transformer at Rowville connected to bus 34.
- Switching the 500/220 kV Rowville A2 transformer from bus 12 to bus 34 and installing a second 500/220 kV transformer at Cranbourne.

More detail on the Eastern Metro RIT-T (which considers the works being completed by the VNI West project) is in Section 3.1.5.

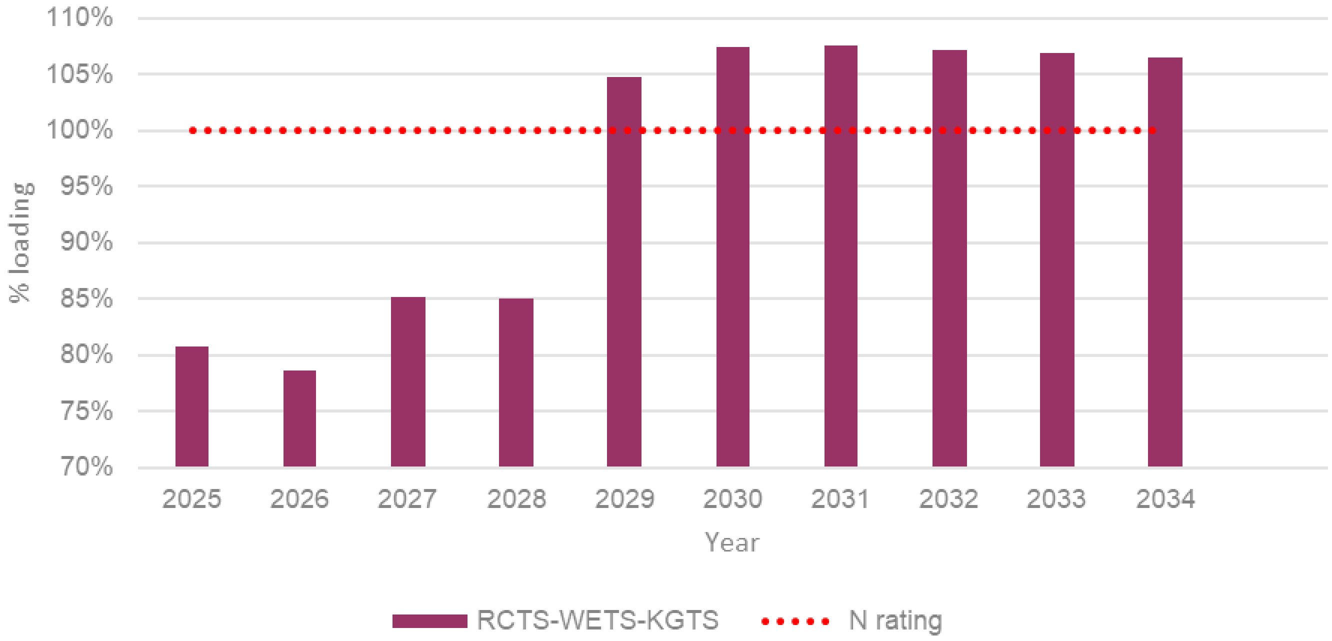
In addition to the Eastern Metro RIT-T, the VNI West project is also completing works to install a power flow controller, or other equipment, on the existing VNI East corridor (anticipated completion 2029), which also helps alleviate the forecast contingency overload on the Eildon – Thomastown 220 kV line.

Red Cliffs – Wemen – Kerang 220 kV line thermal limitation (limitation #8)

Thermal loading on the Red Cliffs – Wemen – Kerang 220 kV line was identified as a monitored limitation in the 2023 VAPR and previous VAPRs and has been elevated to a priority thermal limitation in the 2024 VAPR based on the latest demand forecast. The primary driver of this limitation is the substitution of supply from YWPS with supply from the New South Wales – South Australia interconnector (EnergyConnect) to enter Victoria at Red Cliffs during periods of high demand. It was observed that VNI West significantly reduces the scale of this risk, however it is not able to completely alleviate this limitation.

During peak demand times from summer 2029-30, the loading of Red Cliffs – Wemen - Kerang 220 kV lines is forecast to exceed its 45 degree continuous rating under normal operation (see **Figure 25**).

Figure 25 Overloading of Red Cliffs – Wemen – Kerang 220 kV line under system normal peak demand



Potential options to manage thermal loading on the Red Cliffs – Wemen – Kerang 220 kV line may include, but are not limited to:

- Building a second Red Cliffs – Wemen – Kerang 220 kV line by either building a new single circuit or building a new double circuit and retiring the existing line.
- Installing a power flow controller (or similar device) on the Red Cliffs – Wemen – Kerang 220 kV line to divert flow away from the line at times of high demand.
- Installing a special protection scheme to run back generators to limit the flow from Victorian generators and generators supplying into Red Cliffs from New South Wales.

The feasibility of each option needs further investigation, which will be carried out as part of further studies that may form input to a RIT-T.

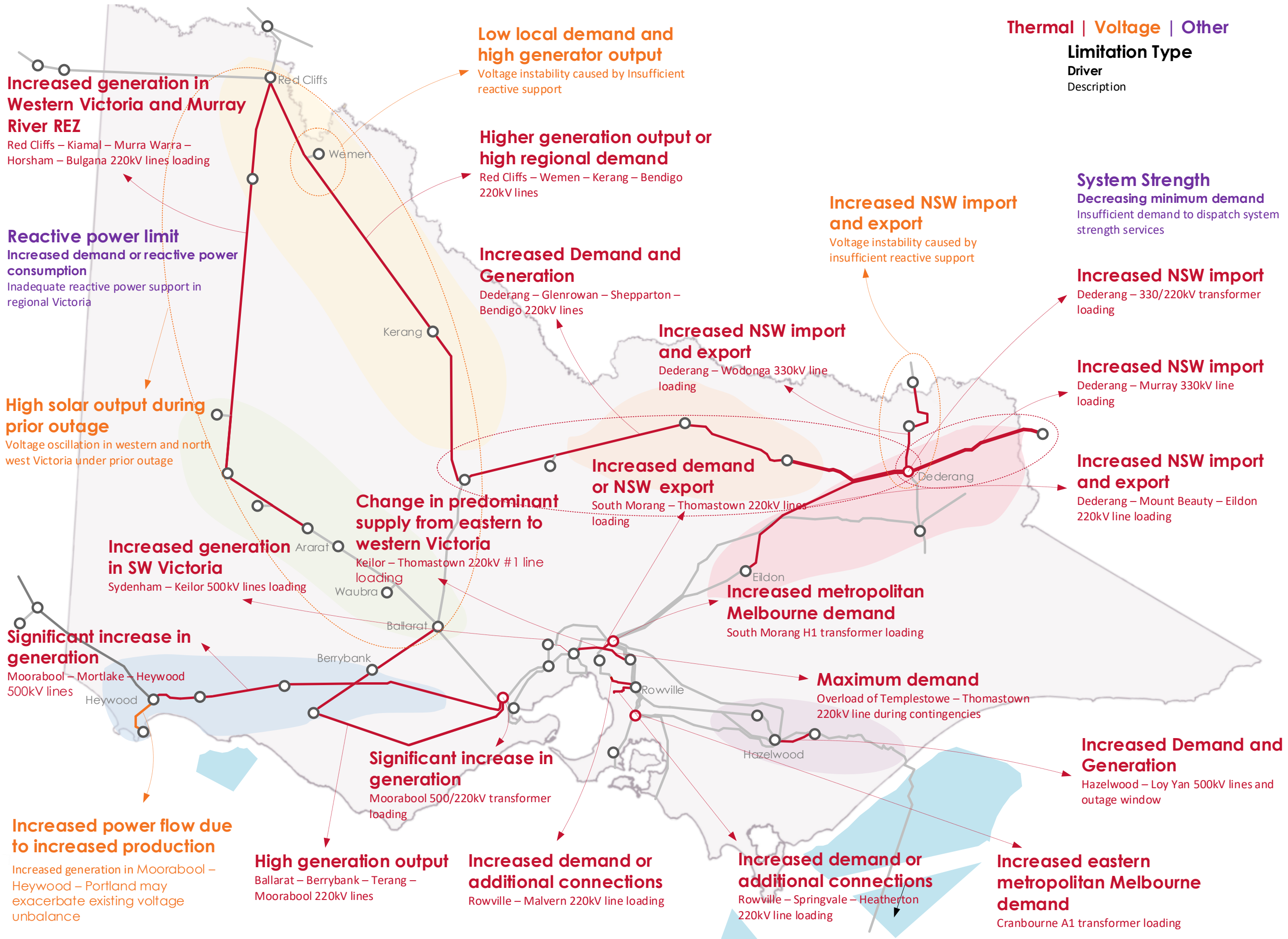
4.2.3 Other limitations (monitored)

AVP continues to monitor transmission network limitations that may result in supply interruptions or constrain generation, but for which either there are no currently identified needs/triggers, or there are insufficient market benefits expected to justify the cost of relieving the limitation. Some of these limitations may be addressed by VicGrid as part of its 2025 Victorian Transmission Plan, which focuses on solutions for increasing REZ transfer capacity.

The following sections provide more detail on new monitored limitations and existing monitored limitations impacted by new anticipated or committed developments in the DSN announced since the 2023 VAPR. These developments may include announced generator connections, transmission augmentations, load forecasts, changes in historical constraint behaviour, or regulatory changes.

While the monitored limitations reported in this VAPR are identified based on the publicly announced Victorian generation expected closure years, AVP has also carried out a sensitivity analysis to assess the impacts on these limitations due to earlier than announced generator retirements and subsequent supply uptake elsewhere, as included in the 2024 ISP *Step Change* scenario. More information is provided in Appendix A2.

Figure 26 Monitored limitations



Thermal limitations

The emergence of new thermal limitations and the benefits of addressing them are heavily dependent on the geography and intermittency of both supply and demand. Patterns of network flow and asset utilisation continue to change in Victoria, due to drivers on the supply side such as a significant amount of new VRE projects, decommitment of large synchronous generation, and strong uptake of distributed PV.

In 2023-24, 360 MW of new generation projects connected in Victoria, and new projects continue to be proposed in regional parts of the state, where high-quality solar and wind resources are abundant (see Section 2.5). These parts of the network, however, were not originally designed to support such high generation density, and a number of investors have faced economic and technical challenges associated with connecting to these areas where sufficient thermal capacity is unavailable. A number of projects have been and are being delivered to address these challenges (see Section 3.1.1). Further projects are likely to be identified through the Victorian Transmission Plan by VicGrid, to facilitate development of REZs over the next 15-25 years.

Northern Corridor – VNI East and Dederang – Wodonga lines

In the 2023 VAPR, thermal loading on the Murray to Dederang 330 kV lines was classified as a monitored limitation. Based on the updated 2024 ESOO demand forecast and a slight decrease in the forecast supply from wind and solar at maximum demand times, there is a forecast increase in import from New South Wales at maximum demand times.

With the forecast increased interconnector flow from New South Wales to Victoria, a new thermal limitation has been identified on the Dederang – Wodonga 330 kV line for the loss of a Dederang to Murray 220 kV line. While this new constraint has been identified from the increased interconnector flow, it has also been observed that existing constraints on VNI East are significantly alleviated from 2028 onwards once VNI West is in service.

Voltage stability limitations

Murray River (V2)

Voltage stability in the Murray River (V2) REZ has ranked highly among the market impact of Victorian network constraints since 2021 when constraints for this limitation were formulated. Since 2021 many projects have been initiated, reducing this limitation to monitored status, including:

- EnergyConnect.
- Koorangie BESS.
- Upgrade of Murraylink VFRB.
- VNI West.

Voltage stability in the Murray River (V2) REZ was previously investigated under anticipated future solar connections. Analysis highlighted a risk that constraints to manage this limitation may have a greater impact if additional solar generation connects prior to commissioning of EnergyConnect, however this risk is significantly mitigated if the anticipated co-located generation and BESS projects are charging during high solar periods. Beyond EnergyConnect and based on the assumptions used in this 2024 VAPR, additional solar capacity is expected to be able to operate with reduced challenges of voltage stability during periods when market conditions allow the additional export capacity to be utilised.

South West Victoria (V4)

Voltage collapse in South West Victoria due to additional generator connections and under high import from South Australia has been managed by applying a constraint since August 2022. In 2023-24 this constraint bound for 171 hours, ranking thirteenth in AVP's constraint impact assessment[72].

In July 2024 the new Cressy TS was connected as part of Stage 1 of Golden Plains Wind Farm, which is anticipated to be completed in 2025. Completion of Cressy TS is expected to improve voltage stability in South West Victoria.

As noted earlier in **0**, the RDP Stage 1 project to turn in the existing Haunted Gully – Tarrone line at Mortlake is anticipated to be completed in October 2025 and is also expected to improve voltage stability in South West Victoria.

AVP anticipates that these augmentations will be sufficient to prevent significant challenges managing voltage stability during system normal conditions under committed and anticipated future connections to the South West

[72] See Section 3.1 of the *Victorian Network Performance and Insights Report*, at https://aemo.com.au/energy-systems/electricity/national-electricity-market-nem/nem-forecasting-and-planning/victorian-planning/victorian-annual-planning-report.

Victoria 500 kV network. Prior to completion of these augmentations in 2025, constraints to address this limitation may temporarily bind more frequently due to recent commitment of additional wind generation in this area.

4.3 System security planning for the DSN

4.3.1 System security criteria

As jurisdictional planner of the Victorian DSN, AVP is responsible for planning the DSN to meet the system security criteria:

- System strength – as the SSSP for Victoria, AVP is responsible for meeting system strength requirements.
- Network Support and Control Ancillary Services (NSCAS) – AVP is responsible for responding to NSCAS gaps declared by AEMO National Planning which need remediation.
- Inertia – AVP is responsible for meeting the requirements to maintain sufficient inertia.

The rapid uptake and build-out of renewable generation and other IBR has resulted in a changing landscape for electricity supply, storage, and demand. A key part of this transition has been the retirement of synchronous generators, such as coal and gas-fired units, that have historically and inherently provided system security and reliability services such as system strength and inertia.

To preserve system security, active procurement of other sources of system strength and inertia is essential to ensure that the network can function securely under the high penetration of IBR, such as solar and wind generation and grid-following batteries, inverter-based loads (IBL), and inverter-based transmission links (Murraylink, Basslink, and MarinusLink when it is established).

4.3.2 System strength requirements

New framework for system strength service provision and obligations

System strength describes the ability of the power system to maintain and control a stable voltage waveform at a given location, during steady state operation and following a disturbance. System strength planning is essential to enable system security to be maintained as grid-following IBR and IBL (which typically demand system strength) connect to the network, and synchronous generators (which supply system strength) retire. Inaction to maintain system strength would ultimately require the use of directions to ensure sufficient synchronous or grid-forming plant are online to maintain a secure power system or, where insufficient synchronous or grid-forming plant is available to be directed, the inability to connect new IBR or IBL, resulting in high costs and/or reduced reliability to consumers.

The revised system strength framework became effective from 2 December 2022 and requires each NEM region's SSSP to plan for and procure a minimum three phase fault level and efficient system strength level, the latter of which caters to the forecast connection of IBR (inclusive of solar, wind and grid-following batteries) and IBL. Both these requirements are detailed in AEMO's annual System Strength Report, which provides a minimum 10-year forecast of the minimum fault level requirement and the IBR and IBL connections for which system strength must be procured.

2023 System Strength Report

Insights and recommendations

The 2023 System Strength Report was published in December 2023 by AEMO in its function as National Transmission Planner providing a 10-year outlook of system strength requirements in the NEM and system strength shortfalls identified from 1 December 2025.

Since the publication of the inaugural report in 2022, AEMO in its function as National Transmission Planner considered whether the identified system strength nodes, along with their minimum fault level requirements, remained consistent with network developments. An outcome of this process was that two possible future system strength nodes, at Mortlake 500 kV Bus 1 and Bulgana 220 kV Bus 1, were identified in Victoria.

Declared and near-term shortfalls

There are no previously declared shortfalls left unaddressed on the DSN prior to December 2025, and no new shortfalls were declared in the 2023 System Strength Report[73].

The report did forecast potential periods where typical dispatch in the absence of system strength investment would not meet the minimum fault level requirements at Hazelwood and Moorabool from 2028-29 onwards, driven by retirement of YWPS. System strength services procured under the new framework from 2 December 2025 through the Victorian System Strength Requirements RIT-T will be dispatched during such periods to meet the system strength standard.

Relevant supporting publications are available in Appendix 3.

Available fault level (AFL) forecasts

The AFL is a metric used to quantify the balance of system strength supply from synchronous and grid-forming sources and system strength demand from grid-following IBR in the power system. Positive AFL indicates locations where system strength will be made available to support additional IBR, while zero or negative AFL indicates locations where system strength to support additional IBR is unavailable and additional investment is currently not planned at the location in the given year.

Forecast AFL is intended to provide locational signals for IBR connections on connection points where system strength will be proactively procured to facilitate connection of IBR.

AVP as SSSP for Victoria must publish a forecast of the AFL at each system strength node over the period for which AEMO has determined system strength requirements, in a manner consistent with the methodology in the System Strength Impact Assessment Guidelines (SSIAG)[74]. AEMO in its function as National Transmission Planner published a methodology for forecasting AFL at system strength nodes in Section 3.4.3 of the 2023 update to the SSIAG. AVP has prepared this AFL forecast (see **Table 15**) in line with the SSIAG for the 2024 VAPR, using the following inputs and assumptions:

[73] At https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/operability/2022/2022-system-strength-report.pdf.

[74] At https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2022/ssrmiag/amendment/system-strength-impact-assessment-guidelines-v21.pdf.

- System strength supply – system strength is supplied from both existing/committed services and new additional services to be determined through the Victorian System Strength Requirements RIT-T.
  - Existing and committed – existing and committed sources of system strength are RDP Stage 1 projects (the Ararat synchronous condenser and the Koorangie BESS), as well as new synchronous condensers located on the New South Wales – Victoria border by Transgrid for the EnergyConnect project.
  - New services – at the time of publication, assessment is still underway to identify a preferred option for provision of system strength services (see Section 3.1.5). For the purpose of this AFL forecast, the timing, location and contribution to AFL of system strength services required to meet the system strength standard are presented in **Table 14**. All credible options considered in the RIT-T will result in a similar AFL as a result of meeting the identified need.

Table 14 Timing and contribution to AFL (MVA) of services to meet the system strength standard (MVA) per financial year

Component of the system strength standard	Location	FY25	FY26	FY27	FY28	FY29	FY30	FY31	FY32	FY33	FY34
To meet the minimum fault level	Hazelwood 500 kV	4,400									
	Hazelwood 220 kV	1,100									
	Moorabool 500 kV	1,100									
To maintain stable voltage waveforms	Hazelwood 500 kV							1,100	1,100		1,100
	Hazelwood 220 kV					1,100					
	Bulgana 500 kV									1,100	
	Moorabool 500 kV					1,100					

- System strength demand – all existing and committed IBR generators and storage as per the July 2024 update to AEMO's Generation Information page[75], and existing direct current (DC) interconnectors Murraylink and Basslink, have been considered.

Table 15 Forecast of available fault level (pre-contingent) at significant Victorian nodes (MVA) per financial year

	FY25	FY26	FY27	FY28	FY29	FY30	FY31	FY32	FY33	FY34
Dederang 220 kV	506	901	1,262	1,301	1,657	1,657	1,774	1,809	2,005	2,088
Hazelwood 500 kV	0	1,021	1,593	1,589	3,690	3,690	4,696	5,650	6,439	7,439
Moorabool 220 kV	0	1,228	1,572	1,464	2,585	2,585	2,893	3,190	3,702	3,936
Red Cliffs 220 kV	0	398	571	617	699	699	722	816	901	920
Thomastown 220 kV	324	969	1,352	1,448	2,420	2,420	2,774	3,085	3,499	3,768
Bulgana 220 kV	0	894	911	1,447	2,053	2,053	2,227	2,432	3,072	3,210
New Kerang 500 kV*								2,640	3,346	3,517
Mortlake 500 kV	0	661	936	926	1,882	1,882	2,121	2,342	2,712	2,881

*New terminal station established by VNI West.

[75] At https://www.aemo.com.au/energy-systems/electricity/national-electricity-market-nem/nem-forecasting-and-planning/forecasting-and-planning-data/generation-information.

System strength locational factors

AVP as SSSP for Victoria must publish the system strength locational factor and corresponding system strength node for each of its system strength connection points. AVP currently has one system strength connection point, where a connection proponent has elected to pay the system strength charge (SSC). The System Strength Locational Factor (SSLF) is one of the variables which must be used along with the System Strength Unit Price (SSUP) to calculate the System Strength Charge (SSC). **Table 16** presents the SSLF and corresponding system strength node for AVP's system strength connection point.

Table 16 System strength locational factors

System strength connection point	System Strength Locational Factor (SSLF)	Corresponding system strength node
Cressy TS 220 kV	1.02	Moorabool 220 kV

4.3.3 NSCAS requirements and related activities

NSCAS are non-market ancillary services that may be delivered to maintain power system security and reliability of supply of the transmission network, or to maintain or increase the power transfer capability of the transmission network. AEMO, in its function as National System Security Planner under the NER, conducts an annual assessment of NSCAS needs and, where required, declares gaps over a five-year horizon.

In the 2023 NSCAS Report[76], AEMO declared an RSAS gap for thermal overloading and voltage control following credible contingences on the 220 kV network near Deer Park TS. AVP has commenced the following activities to address the identified gaps as below:

- Thermal overloading – AVP has commenced the Western Metro Melbourne reinforcement RIT-T to address the thermal overloading prefeasibility studies and plans to publish the first report, the PSCR by Q1 2025), as detailed in section 3.1.5.
- Voltage control – the voltage management needs are being addressed through the broader Metropolitan Melbourne Voltage Management RIT-T, the PACR for which is planned for publication by Q4 2025, as detailed in section 3.1.5.

NSCAS studies also confirmed overloading risk on transformers between the 500 kV and 220 kV network supplying metropolitan Melbourne from early 2029 following the closure of YWPS. AVP proposed a preferred a switching arrangement that would reconfigure the Latrobe Valley network into the modified parallel mode described in section 3.1.2, to alleviate these constraints in the short term. AVP has also initiated the Eastern Metro Melbourne Reinforcement RIT-T to alleviate thermal constraints in metropolitan Melbourne including this shortfall in the long term (see section 3.1.5).

4.3.4 Inertia outlook and planned activities

Inertia is responsible for arresting frequency changes after a contingency event in the power system. Conventionally, inertia is provided by large synchronous machines.

[76] See https://aemo.com.au/-/media/files/electricity/nem/security_and_reliability/system-strength-requirements/2023-nscas-report.pdf.

The retirement of large synchronous generation, towards a grid dominated by inverter based VRE generators and decentralised CER, has reduced the availability of sources able to provide sufficient inertia for the network. AEMO publishes immediate five-year projections of inertia requirements and shortfalls on an annual basis, by examining each region in the NEM under both system normal and islanded operating conditions. The latest changes are in the 2023 Inertia Report[77], where AEMO identified the following for Victoria:

- Inertia will decline over the immediate five-year period, with expectations that the secure operating level and minimum threshold of inertia will not be reached when examining Victoria as an island (**Figure 27**).
- Despite this, no formal inertia shortfall has been declared in the state due to the number of interconnectors joining Victoria and neighbouring regions.
- No inertia shortfall for the sub-region of Victoria and South Australia has been declared. A previous shortfall, starting from July 2026, was identified in the 2022 Inertia Report, but its removal in the latest report is justified by the commissioning of Humelink in calendar year 2027 (**Table 17**).

Figure 27 Projected inertia for the five-year outlook, *Step Change* scenario, Victoria (megawatt seconds (MWs))

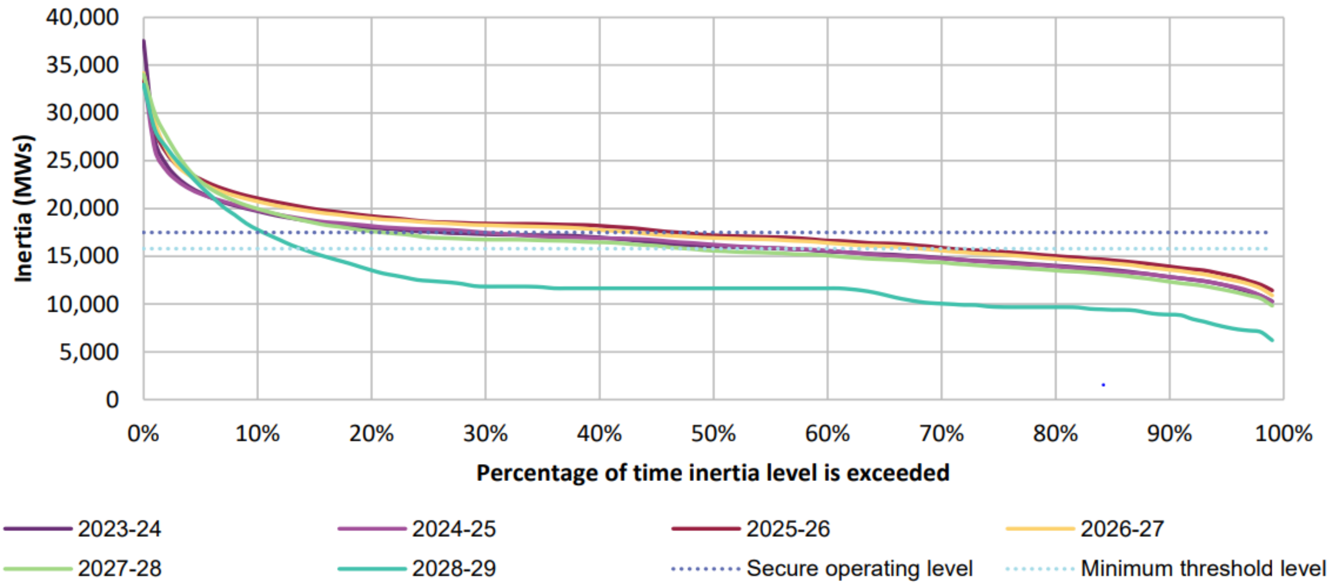


Table 17 Inertia requirements and projections for South Australia and Victoria (from 2023 Inertia Report)

For South Australia and Victoria	2023-24	2024-25	2025-26	2026-27	2027-28	2028-29
Assumed level of 1-second FCAS (MW)	212	212	212	212	212	212
Minimum threshold level of inertia (MWs)	15,800	15,800	15,800	15,800	15,800	15,800
Secure operating level of inertia (MWs)	17,500	17,500	17,500	17,500	17,500	17,500
Available inertia 99% of the time (MWs)	17,598	17,964	18,584	18,032	17,000	13,588
Calculated inertia deficit (MWs)	0	0	0	0	500	3,912
Likelihood of combined regions islanding	Likely	Likely	Likely	Unlikely	Unlikely	Unlikely
Declarable inertia shortfall (MWs)	-	-	-	-	-	-

[77] At https://aemo.com.au/-/media/files/electricity/nem/security_and_reliability/system-strength-requirements/2023-inertia-report.pdf.

There has been continued work by jurisdictional planning bodies and TNSPs to identify emerging sources able to deliver inertia under the system strength framework. These include flywheels added to new synchronous condensers (at minimum cost), and fast frequency response capabilities from grid-forming batteries.

The final determination published by the Australian Energy Market Commission (AEMC) on *Improving security frameworks for the energy transition* in May 2024 has implications for inertia provision:

- A NEM-wide inertia floor has been introduced.
- Inertia can now be declared as an NSCAS gap, in the immediate three years.
- The inertia requirement is now parallel to existing islanded requirements, of which jurisdictional planning bodies such as AVP must procure for the larger of the two.

Procurement of inertia is aligned with procurement of system strength:

- A 10-year inertia requirement forecast will now be published by AEMO.
- AVP must procure three years ahead of time.

The 2024 Inertia Report, to be published by AEMO National Planning by 1 December 2024, will incorporate these updated inertia requirements. AVP will assess these requirements as part of the 2025 Annual Planning Review and, where appropriate and practicable, will aim to consider these requirements in later stages of its Victorian System Strength Requirement RIT-T.

4.4 Control schemes in the DSN

This section provides information about the activities undertaken by AVP in compliance with NER 5.12.2, which states that TNSPs' Annual Planning Reports must address:

- For proposed new or modified emergency frequency control schemes, the manner in which the project relates to the most recent General Power System Risk Review (GPSRR), including any identified risks or recommendations relevant to system stability and frequency control.
- The emergency controls implemented under NER 5.1.8, including the NSP's assessment of the need for new or altered emergency controls under that clause.
- The analysis of the operation of, and any known or potential interactions between:
  - any emergency frequency control schemes or emergency controls place under NER 5.1.8, on its network; and
  - protection systems or control systems of plant connected to its network (including consideration of whether the settings of those systems are fit for purpose for the future operation of its network).

This analysis includes a description of proposed actions to be undertaken to revise these schemes or controls or systems, or to address any adverse interactions.

4.4.1 Need for new control schemes and ongoing review of existing control schemes

Since the 2023 VAPR, AVP has reviewed and updated a set of existing control schemes (see Section 3.1 for more information on delivered control scheme updates). Currently AVP is progressing the review of another set of existing control schemes and the development of new schemes to address the GPSRR's recommendations as well as support planned projects including AVP initiated projects, RDP Stage 1 projects directed by the Victorian Government, and major network changes in neighbouring states through joint planning with the relevant TNSPs.

The next few sections summarise AVP's review and development activities related to the control schemes, segregated into the main transmission corridors.

4.4.2 South Western corridor

- AVP is investigating the need for new control schemes and modifications to existing control schemes in this corridor, including the Emergency APD Potline Tripping (EAPT) control scheme and Generation Fast Tripping (GFT) schemes), jointly with ElectraNet and TransGrid, to address a risk identified in the 2023 GPSRR[78].
- AVP has identified the need for a new control scheme to manage periods with high South Western generation and high Heywood interconnector import into Victoria. Given the large number of renewable generation connections in this corridor and the HIC transfer capacity increase following the EnergyConnect project, the loss of both Moorabool – Sydenham 500 kV lines may lead to instability in the Metro Melbourne region. AVP is conducting power system studies to determine functional requirements for the new control scheme.
- AVP is progressing the implementation of a new Ballarat – Terang – Moorabool thermal loading control scheme, which is an RDP Stage 1 minor augmentation project. See **Table 6** in Section 3.1 for more details on this project.
- AVP is currently investigating the need for a new scheme to manage potential instability for double circuit contingencies of the new 500 kV lines to be built as part of the WRL and VNI West projects jointly with TransGrid. See Section 3.1 for more information about WRL and VNI West.
- As part of EnergyConnect, ElectraNet has commissioned Stage 1 of the SAIT RAS, which includes a Victorian component delivered by AVP to detect relevant outages of 500 KV network components between Heywood and Moorabool. See Section 3.1.2 for more information on EnergyConnect and the SAIT RAS.

4.4.3 North West Corridor

- AVP is currently modifying the existing Murraylink VFRB scheme, which addresses voltage instability under contingency scenarios in the North West region when Murraylink exports to South Australia to cater for network changes as a result of EnergyConnect Stage 1. The scheme will now be initiated following a non-credible contingency of the Buronga – Red Cliffs 220 kV line and will be commissioned as part of EnergyConnect Stage 1.

[78] The 2023 GPSRR identified that there was a potential for Moorabool contingency events to result in separation of the mainland NEM into four islanded areas – Queensland, South Australia, the network between Heywood and Moorabool, and the rest of New South Wales and Victoria.

- AVP has also completed EnergyConnect Stage 2 impact studies on the existing Murraylink VFRB scheme and the Murraylink Slow Run Back (SRB) scheme. Minor modifications are required on the Murraylink SRB scheme only.
- As part of the RDP Stage 1 minor augmentation projects, AVP is progressing:
  - A new control scheme to manage thermal overloading on Red Cliffs – Kiamal – Murra Warra – Horsham – Bulgana 220 kV network, by adding a new function to the existing Murraylink VFRB scheme, to run back Murraylink while importing into Vic (Murraylink VFRB-import). Currently AVP is investigating the impact of EnergyConnect Stage 2 on this new Murraylink VFRB-import scheme.
  - A new control scheme to manage thermal overloading on Dederang – Glenrowan – Shepparton – Bendigo 220kV network.

See **Table 8** in Section 3.1 for more details on these RDP stage 1 projects.

4.4.4 VNI East (Northern corridor)

- AVP is currently reviewing the settings of the Dederang Bus Splitter Scheme (DBUSS) transformer control scheme to cater for the recent rating upgrade of the Dederang TS (DDTS) H3 330/220 kV transformer as a result of an RDP Stage 1 project. See section 3.1.2 for more information on the RDP project which enables the remote control of the cooling system of the DDTS H3 transformer.
- AVP, jointly with Transgrid, is still investigating the need for a new scheme to address a risk[79] identified in the 2022 Power System Frequency Risk Report (PSFRR).

4.4.5 Review of other schemes in the wider Victorian DSN

In line with the requirements of NER 5.1.8 and in addition to the activities mentioned above in this control scheme section, AVP continuously monitors changes in network configuration and operating conditions, including connection point demand, new generation connections and retirements of existing generation, and will upgrade the Victorian control schemes as necessary to ensure their effectiveness and appropriateness.

4.5 General Power System Risk Review – planned activities

The GPSRR is an integrated, annual review of major power system risks in the NEM. AEMO, in accordance with NER 5.20A.3, undertakes this review in consultation with TNSPs. AEMO published its 2024 GPSRR report in July 2024. The 2024 GPSRR is available on AEMO's website[80].

There was one Victorian risk and recommendation in the 2024 GPSRR (Risk 1): a fault on the Loy Yang B unit 2 transformer followed by the failure of the single bus coupler circuit breaker (CB) that connects the 500 kV No. 3 bus and Loy Yang B unit 2. This non-credible contingency would result in backup protection operating that, under certain operating conditions, could result in the loss of up to approximately 1,300 MW of generation in Victoria. Studies in the 2024 GPSRR indicate that due to the configuration of Loy Yang 500 kV station, this non-credible

[79] The 2022 Power System Frequency Risk Report (PSFRR, the predecessor to the GPSRR) identified potential voltage instability following the loss of the Dederang – South Morang 330 kV and Thomastown – Eildon 220 kV line during high VNI export to New South Wales.

[80] At https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/system-operations/general-power-system-risk-review.

contingency could result in severe cascading failures, particularly when operating with certain minimum synchronous generator combinations.

Given the criticality of the site for system reliability and security, AEMO recommended that AVP design and implement a suitable solution to improve the overall resilience of the Loy Yang 500 kV station as a priority and share its findings with AEMO for consideration in future GPSRRs.

In response to the above GPSRR recommendation, AVP is investigating options to address this risk.

4.6 Joint planning activities to maintain the DSN

AVP, as the Victorian TNSP, conducts joint planning to achieve the most efficient whole of system outcome for consumers. Other NSPs, including neighbouring TNSPs and DNSPs, are engaged when identifying network needs to plan the network and facilitate new connections.

While previous sections have focused on the need for network augmentation, appropriate maintenance of Victoria's existing network remains critical. In 2024, AEMO has again worked closely with DTSOs to assess the need for the replacement, refurbishment, derating, or retirement, of existing DSN assets that are approaching end-of-life. AusNet Services (Transmission) is currently the only DTSO with DSN asset replacement and refurbishment plans over this forecast period.

4.6.1 Joint planning in relation to replacement retirement or de-ratings of DSN assets

In the 2024 VAPR:

- AusNet Services' 2024 asset replacement and refurbishment plans are largely consistent with those presented in the 2023 VAPR.
- Two major DSN asset replacement projects have been delivered since the 2023 VAPR:
  - Loy Yang Power Station (LYPS) and Hazelwood Terminal Station (HWTS) 500 kV Circuit Breaker Replacement Stage 1.
  - Heywood Terminal Station (HYTS) 500 kV switchgear replacement.
- One asset renewal project is being delivered:
  - HWTS A2, A3 and A4 500/220 kV Transformer Refurbishment.
- Five new asset replacement projects have been identified, or have now moved within the assessment horizon:
  - Gas Insulated Lines (GIL) Replacement at Rowville Terminal Station (ROTS).
  - Moorabool Terminal Station (MLTS) A1 1000 MVA 500/220 kV Transformer and 220 kV Shunt Reactor Replacement.
  - Rectification of low transmission line conductor spans.
  - HYTS to APD 500 kV tower replacement, Stage 2 (includes replacement of conductors and earth wires).
  - Anakie 500 kV transmission tower rebuild.

4.6.2 Asset replacement, retirement and de-ratings in the DSN

Roles and responsibilities

In Victoria, DTSOs build, own, and operate transmission network infrastructure.

Each DTSO is responsible for assessing the condition of its Victorian DSN assets, and for making replacement, retirement, or derating decisions for those assets. As the Jurisdictional Planning Body (JPB) for Victoria, AVP's primary involvement is in providing planning advice to the relevant DTSO (particularly on the continued system need for individual DSN assets).

Many transmission assets in the DSN were built several decades ago and are approaching end of service life. Asset condition, shifts in technology and changing demand forecasts drive an increasing need to coordinate DSN asset renewal and augmentation activities in Victoria, and to assess both the system need and economic justification for the replacement of existing assets.

Rule requirements for DSN asset retirements/de-ratings

TAPRs must include detailed information relating to all network asset retirements and deratings that would result in a network constraint over the planning period. AusNet Services' current asset renewal plan is available alongside the VAPR on AEMO's website[81]. Details of current replacement RIT-Ts are also available at AusNet Services' website[82].

Where there is an identified need to retain an asset, AVP and AusNet Services conduct joint planning to identify the most efficient and economic option to address the identified need. The following sections provide more information about the joint planning process for asset retirement, replacement, refurbishment, and deratings.

Methodology

AVP and AusNet Services agreed on the approach for joint planning adopted in this VAPR:

- AVP and AusNet Services jointly selected a set of assets which are included in AusNet Services' Asset Renewal Plan that are likely to create a DSN constraint and potentially justify RIT-Ts for replacement.
- The selected assets were grouped with their associated network components whenever possible, and a need assessment was conducted by assessing the overall network impacts of retiring the asset.
- Circuit breakers, other switchgear, and secondary systems were grouped with their respective associated network components, such as transmission circuits, transformers, generators, or reactive plants whenever possible.
- Committed projects, projects for which RIT-Ts have been completed, and projects associated with transmission assets that do not form part of the DSN were excluded from the network need assessment.

[81] At https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/nem-forecasting-and-planning/victorian-planning/victorian-annual-planning-report.

[82] See https://www.ausnetservices.com.au/projects-and-innovation/regulatory-investment-test.

- AVP did not assess the need to replace line insulators or conductors in the usual case where this amounts to less than 5% of the line replacement cost, as this cost, and system impact of line retirement, do not comprise a meaningful cost-benefit assessment.
- Most of the secondary equipment (such as communication systems and control batteries), structural assets (for example towers), and ground wires in the Asset Renewal Plan were excluded from the network need assessment for individual projects. These assets are considered essential to the associated DSN primary network components, and therefore they will be needed while the associated primary network components are still in service. As there is no committed retirement of Victorian transmission lines or Victorian interconnectors at present, AVP and AusNet Services agreed that all the secondary and structural assets which are associated with the Victorian transmission lines and interconnectors are still required, without carrying out need assessment on individual projects.
- AVP undertook a desktop analysis to assess whether the retirement of the selected asset would result in a network impact (that is, a network need for its replacement). In the case of an asset retirement that causes the disconnection of a generator, the resulting reduction in supply availability was also considered.
- If the proposed retirements would cause line, transformer, or Static Var Compensator (SVC) outages, the impact of a credible contingency under worst-case operational conditions (normally either maximum or minimum demand conditions) was examined with a prior outage of the respective network element.

Needs assessment results

Table 18 presents the summarised findings from the assets needs assessment.

Table 18 Network needs assessment results

Project name	Location	Total cost (real $M)	Target completion (December)	Major DSN assets component(s) affected	Retirement outcome
Anakie 500 kV Transmission tower rebuild	T134 - T136 SYTS-MLTS 1 & 2	40	2025	Sydenham – Moorabool lies No. 1 and No. 2	Reduced reliability and capability to supply Western Melbourne load, and reduced generation supply reliability in Western and South Western Victoria.
HYTS – APD 500 kV line replacement Stage 1	HYTS-APD line, T624- T628B	48	2026	Heywood – Alcoa Portland lines No. 1 and No. 2 Selected towers, conductors, and ground wire	Loss of connection to Alcoa Portland and embedded wind farms, reducing supply reliability.
Rectification of low transmission line conductor spans for ground clearance < 6m at maximum operating temperature	Transmission lines	25	2027	Forty spans across nine DSN circuits	Major reductions in reliability, interconnector capabilities and ability to meet demand across the network. Generation constraints.
HYTS – APD 500 kV line replacement, Stage 2	HYTS-APD line, T605- T623	110	2028	Heywood – Alcoa Portland lines No. 1 and No. 2 Selected towers, conductors, and ground wire	Loss of connection to Alcoa Portland and embedded wind farms, reducing supply reliability.
Rowville Terminal Station GIL Replacement	Rowville Terminal Station	30	2028	Rowville – South Morang 500 kV line Rowville – Thomastown 220 kV line	Reduced reliability and interconnector capabilities
Keilor 500/220kV Transformer Replacement	Keilor Terminal Station	150	2029	A2, A3 and A4 750MVA 500/220kV transformers No.1 220kV capacitor bank circuit breakers B4 150 MVA 220/66 kV transformer	Reduced reliability and capability to meet peak demand under certain operating conditions[83] .
South Morang Terminal Station 500 kV GIS and F2 Transformer Replacement	South Morang Terminal Station	180	2029	South Morang – Hazelwood 500 kV lines No. 1 and No. 2 South Morang – Sydenham 500 kV lines No. 1 and No. 2 South Morang – Rowville 500 kV No.3 line South Morang – Keilor 500 kV line F2 1000 MVA 500/330 kV transformer	Reduced reliability, interconnector capabilities and ability to meet demand.

[83] AusNet Services and AEMO will continuously work together to determine the preferred option in replacing the existing Keilor transformers.

Project name	Location	Total cost (real $M)	Target completion (December)	Major DSN assets component(s) affected	Retirement outcome
Thomastown Terminal Station Circuit Breaker Replacement	Thomastown Terminal Station	25	2029	Thomastown 220 kV No. 1 and 66 kV 4B capacitor bank circuit breakers	May reduce maximum supportable demand caused by reduced reactive power margin[84].
Rowville Terminal Station 220 kV Circuit Breaker Replacement	Rowville Terminal Station	15	2029	Rowville No. 1 and No. 2 Static Var Compensation Rowville 220 kV capacitor bank circuit breakers ROTS-SVTS No. 2 line and A1 500/220 kV transformer	Reduced reliability and capability to meet peak demand and reduced maximum supportable demand.
South Morang 330/220 kV Transformer Replacement	South Morang Terminal Station	80	2030	South Morang H1 700 MVA 330/220 kV transformer Spare 700 MVA 330/220 kV transformer	Reduced reliability and capability to meet peak demand.
LYPS and Hazelwood Terminal Station 500 kV Circuit Breaker Replacement Stage 2	LYPS Switchyard and Hazelwood Terminal Station	60	2030	Loy Yang – Hazelwood 500 kV No. 1 line double breaker switch bay Loy Yang – Hazelwood 500 kV No. 2 line Loy Yang – Hazelwood 500 kV No. 3 line Hazelwood – Loy Yang 500 kV No. 2 line Hazelwood – Loy Yang 500 kV No. 3 line Hazelwood – Rowville 500 kV No. 3 line breaker-and-half switch bay (Hazelwood end) Hazelwood – Cranbourne 500 kV No. 4 line breaker-and-half switch bay (Hazelwood end)	Generation constraints and reduced reliability.
Newport Power Station 220 kV Gas Insulated Switchgear (GIS)	Newport Power Station Switchyard	70	2031	Newport – Brooklyn 220 kV line Newport – Fishermans Bend 220 kV line	Loss of connection to Newport generation (noting Newport expected closure year is 2039).
Loy Yang 66 kV Circuit Breaker Replacement	Loy Yang 66 kV Switch Yard	20	2031	Loy Yang – Morwell 66 kV line No. 1, 2, 3 and 4 Loy Yang 66 kV capacitor banks No. 1 and No. 2	Loss of supply for emergency fire services (noting expected closure of Loy Yang coal-fired generators commencing 2035).

[84] In addition to maximum supportable demand, AEMO also assessed the impact of in-service 220 kV or 66 kV cap banks on Victorian import voltage stability limits and voltage control. Study results indicated that retiring any existing capacitor bank could reduce the Victorian import voltage stability limit from New South Wales, however not all capacitor banks are required to be in-service at the same time for voltage control. Further studies using a voltage stability assessment tool (VSAT) has also confirmed the impact of these capacitor banks on Victorian import voltage stability limit. The retirement impacts of capacitor bank circuit breakers and their associated capacitor banks are inter-dependent. See https://aemo.com.au/initiatives/major-programs/metropolitan-melbourne-voltage-management-regulatory-investment-test-for-transmission.

Project name	Location	Total cost (real $M)	Target completion (December)	Major DSN assets component(s) affected	Retirement outcome
Morwell Terminal Station 66 kV Circuit Breaker Replacement	Morwell Terminal Station	10	2031	Morwell to Loy Yang 66 kV lines No. 3 and No. 4	Loss of supply for Loy Yang raw coal bunker emergency fire services, potentially resulting in no Loy Yang generation (A or B) for up to six months.
Dederang Terminal Station H3 330/220 kV Transformer and Circuit Breaker Replacement	Dederang Terminal Station	80	2032	H3 340 MVA 330/220 kV transformer and two 330 kV circuit breakers	Reduced reliability and capability to supply Wodonga (330 kV), Mt Beauty and Glenrowan (220 kV) and reduced Victoria to New South Wales export capability.
Geelong 220 kV and 66 kV Circuit Breaker Replacement	Geelong Terminal Station	20	2032	GTS-MLTS No. 2 220 kV circuit breaker GTS No.1 BUS – KTS No. 3 220 kV circuit breaker	Reduced reliability to supply Geelong and Deer Park area load[85].
YWPS 220 kV Circuit Breaker Replacement – Stage 2	Yallourn W Power Station	35	2032	Yallourn – Rowville 220 kV lines No. 5 and No. 6 Yallourn – Hazelwood 220 kV lines No. 1 and No. 2	Reduced reliability and capability to supply Melbourne eastern metro load[86]. Following retirement of YWPS, these assets are still required to transfer power from the Latrobe Valley to metropolitan Melbourne.
Moorabool Terminal Station A1 Transformer and Shunt Reactor Replacement	Moorabool Terminal Station	65	2033	1,000 MVA 500/220 kV transformer, one 220 kV shunt reactor and two 500 kV shunt reactors	Reduced reliability to supply Geelong and Deer Park area load. Reduced ability to manage over-voltage during periods of low demand.

Asset retirements

DSN assets planned for retirement, and not forming part of AusNet's Asset Renewal Plan, are detailed in **Table 19Table 19**.

[85] Replacement of these assets may be incorporated into augmentation options for upgrading GTS-MLTS and the Western Metro network.

[86] Hazelwood transformation allows continued utilisation of Latrobe Valley to Melbourne 220 kV lines to supply Melbourne eastern metro load.

Table 19 Asset retirements in the DSN

Location	Asset to be retired	Expected retirement date	Retirement outcome
Horsham Terminal Station	Static Var Compensator (SVC)	Mid-2026	Reduced ability to maintain voltages within limits in North West Victoria. Dynamic voltage and reactive power requirements will be addressed by the Ararat synchronous condenser to be installed under RDP Stage 1 (Section 3.1.2).
Tyabb Terminal Station	45 MVAr 66 kV capacitor bank	FY 2027-28	Reduction in maximum supportable demand in Cranbourne and Tyabb. Some alleviation in 2029-30 from changes in network configuration in Latrobe Valley post YWPS retirement and introduction of VNI West. However, further investment required to address the reactive shortfall in later years. Investment options are discussed in AVP's Melbourne Metropolitan Voltage Management RIT-T (Section 3.1.5).
Rowville Terminal Station	200 MVAr 220 kV capacitor bank No.1	FY 2027-28	Contributes to reduction in maximum supportable demand in Malvern, Heatherton and Springvale. Some alleviation in 2030 due to VNI West, however investment required to address the reactive shortfall in later years. Investment options are discussed in AVP's Melbourne Metropolitan Voltage Management RIT-T (Section 3.1.5).
Templestowe Terminal Station	50 MVAr 66 kV capacitor bank	FY 2027-28	Contributes to reduction in maximum supportable demand in Malvern, Heatherton and Springvale. Some alleviation in 2030 due to VNI West, however investment required to address the reactive shortfall in later years. Investment options are discussed in AVP's Melbourne Metropolitan Voltage Management RIT-T (Section 3.1.5).
Altona Terminal Station	200 MVAr 220 kV capacitor bank	FY 2027-28	Contributes to reduction in maximum supportable demand in metropolitan Melbourne.
Moorabool Terminal Station	150 MVAr 220 kV capacitor bank No.2	FY 2027-28	Contributes to reduction in maximum supportable demand in metropolitan Melbourne.
Dederang Terminal Station	100 MVAr 220 kV capacitor bank	FY 2027-28	Minor contribution to voltage collapse in southern New South Wales following loss of large Victorian generation or Basslink, during periods of import from New South Wales.
Dederang Terminal Station	225 MVAr 330 kV capacitor banks No. 1 and No. 2	FY 2027-28	Contract expires in December 2027. AVP intend to assess the network need to retain reactive support at Dederang.

4.6.3 Asset replacement RIT-Ts

AusNet Services completed RIT-Ts for the following asset renewal projects since publication of the 2023 VAPR:

- MSS-DDTS 1 and 2 lines tower strengthening.
- Transmission Line Insulator Replacement Program.
- AusNet Services is progressing several DSN asset renewal project RIT-Ts on primary and secondary assets as detailed below.

Conductor and ground wire replacement – Phase 1

AusNet Services commenced this RIT-T to identify the preferred option to replace ageing conductors and ground wires. This RIT-T is needed to:

- Maintain the required reliability of transmission network services across its transmission network, through actively managing the risks and consequences of conductor or ground wire failures.
- Ensure that it complies with its regulatory obligations, including those in the *Electricity Safety Act 1998.*

AusNet Services published the PADR in April 2023[87] and intends to publish the PACR by the end of 2024.

Tower replacement on the Heywood to Alcoa Portland 500 kV line

AusNet Services commenced this RIT-T to identify the preferred option of corrosion management for towers along the HYTS-APD 500 kV lines. This RIT-T is needed to:

- Maintain the required reliability of supply to the Portland Aluminium smelter, through actively managing the risks and consequences of tower failure.
- Ensure that it complies with its regulatory obligations, including those in the *Electricity Safety Act 1998.*

AusNet Services published the PSCR in February 2024[88] and intends to publish the PACR by the end of 2024.

Maintaining reliable transmission network services at South Morang Terminal Station (SMTS)

AusNet Services commenced this RIT-T to identify the preferred option of replacing 500 kV Gas Insulated Switchgear (GIS) and the F2 500/330 kV transformer. This RIT-T is needed to:

- Maintain the required reliability of transmission services at SMTS, through actively managing the risks and consequences of:
  - 500 kV switchgear failure, and
  - 500/330 kV transformation failure.
- Ensure that it complies with its regulatory obligations, including those in the *Electricity Safety Act 1998.*

[87] See *Conductor & Ground Wire Replacement* PADR, at https://www.ausnetservices.com.au/-/media/project/ausnet/corporate-website/files/about/regulatory-investment-test/2023/dpar_ground-wire.pdf.

[88] See *Tower replacement on the Heywood to Alcoa Portland 500kV line* PSCR, at https://www.ausnetservices.com.au/-/media/project/ausnet/corporate-website/files/about/regulatory-investment-test/2024/rit-t_tower-replacement-hyts-apd-_pscr.pdf.

AusNet Services published the PSCR in June 2024[89] and intends to publish the PACR by the end of 2024.

Maintaining reliable transmission network services at Keilor Terminal Station (KTS)

AusNet Services commenced this RIT-T to identify the preferred option of replacing three 750 MVA 500/220 kV transformers. This RIT-T is needed to:

- Maintain the required reliability of transmission services at KTS, through actively managing the risks and consequences of transformation failure.
- Ensure that it complies with its regulatory obligations, including those in the *Electricity Safety Act 1998.*

AusNet Services published the PSCR in July 2024[90] and intends to publish the PACR by mid-2025.

AusNet Services and AVP will continuously work jointly to determine the preferred replacement option for the existing Keilor transformers, optimising the solution for any augmentation needed to support increasing demand in the western metropolitan area.

Maintaining reliable 330/220 kV transformation network services at South Morang Terminal Station (SMTS)

AusNet Services commenced this RIT-T to identify the preferred option of replacing two 700 MVA 330/220 kV transformers. This RIT-T is needed to:

- Maintain reliable 330/220 kV transformation network services at SMTS and to mitigate risks from asset failures.
- Ensure that it complies with its regulatory obligations, including those in the *Electricity Safety Act 1998.*

AusNet Services published the PSCR in August 2024[91] and intends to publish the PACR by mid-2025.

AusNet Services and AVP will continuously work jointly to optimise the solution to satisfy asset renewal and augmentation plans at SMTS.

More details are provided in AusNet Services' asset renewal plan, which is available with the VAPR on AEMO's website. Details of current RIT-Ts are also available at AusNet Services' website[92].

4.6.4 Joint planning activities with other TNSPs

AVP as a TNSP has an obligation to undertake joint planning with neighbouring TNSPs if:

- a possible credible option to address a constraint in a transmission network is an augmentation to the transmission network of another TNSP; and
- the constraint is not already being considered under other processes under the NER.

[89] See *Maintaining reliable transmission network services at South Morang Terminal Station* PSCR, at https://www.ausnetservices.com.au/-/media/project/ausnet/corporate-website/files/about/regulatory-investment-test/2024/smts-gis-replacement-pscr_v1.pdf.

[90] See *Maintaining reliable transmission network services at Keilor Terminal Station* PSCR, at https://www.ausnetservices.com.au/-/media/project/ausnet/corporate-website/files/about/regulatory-investment-test/2024/kts-transformer-replacement-pscr.pdf.

[91] See *Maintaining reliable 330/220 kV transformation network services at South Morang Terminal Station* PSCR, at https://www.ausnetservices.com.au/-/media/project/ausnet/corporate-website/files/about/regulatory-investment-test/2024/smts-h-transformer-replacement-pscr_final.pdf.

[92] See https://www.ausnetservices.com.au/projects-and-innovation/regulatory-investment-test.

AVP has been working closely with neighbouring TNSPs for augmentation works involved with upgrades to the existing interconnectors and planned new interconnectors including EnergyConnect, VNI West and MarinusLink. This includes:

- Any inter-network testing associated with any project that augments interconnectors.
- Developing control schemes which could affect power system performance in multiple states or respond to recommendations from the GPSRR.

See Section 3.1 for more details about EnergyConnect and VNI West projects, and Section 4.4 for more information about Victorian control schemes.

Inter-network tests associated with the EnergyConnect project

Following completion of inter-network testing on Stage 1 EnergyConnect, AEMO and ElectraNet plan to enhance the transfer capacity of HIC by conducting a series of tests to validate new transfer limits. The works will result in a new limit of 650 MW import and 650 MW export.

An inter-network test program[93] has been developed by Transgrid, ElectraNet, AVP and consulted with AEMO and will be used to:

- Quantify the impact of the increased transfer across HIC on damping of modes of oscillation, to ensure they meet NER compliance requirements.
- Validate interconnector power transfer capability.
- Ensure the satisfactory coordination of transmission equipment and generator plant control systems.
- Identify potential operational issues at increased transfer, such as interconnector drift management issues.
- Identify any unmodelled phenomena.

4.6.5 Joint planning activities with DNSPs

Each TNSP must conduct joint planning with each DNSP of the distribution networks to which the TNSP's networks are connected. To meet this requirement, AVP attends regular joint planning meetings with each Victorian DNSP and closely work with the relevant DNSP to ensure efficient planning outcomes and to identify the most efficient options to address the following issues.

Distribution fault level

AEMO must, when planning the DSN, use its best endeavours to ensure that fault levels at a connection point will not, as a result of a short circuit at that connection point, exceed 21.9 kiloamperes (kA) due to a short circuit at that 66 kV connection point or 26.2 kA at the 22 kV connection point, except where agreed derogations between AVP and the DNSP apply. In its 2023 annual maximum fault level review, under the worst case scenario[94], AVP identified the following sites:

[93] See https://aemo.com.au/en/consultations/current-and-closed-consultations/project-energyconnect-stage-1-and-hic-capacity-release---inter-network-test-program.

[94] That is, with all fault current sources connected and all network components in service.

- Geelong Terminal Station (GTS) 66 kV fault levels could exceed the 21.9 kA limit whenever the GTS 66 kV buses are tied together due to increased fault contribution from upstream generators. Under the current operational arrangement, the GTS 66 kV buses are operated in a split arrangement to manage the fault level and are only tied together automatically following a GTS 220/66 kV transformer contingency by a Normally-Open-Auto-close (NOAC) control scheme.
  - AVP is working with AusNet Services and Powercor in developing a plan to manage fault levels at Geelong 66 kV buses, considering future connections and network projects. Long-term solutions include installing new series reactors, circuit breaker upgrades and viable long-term network reconfigurations. Given that it will take time to identify and implement a preferred long-term solution, Powercor and AusNet have implemented the short-term solution of disabling the NOAC control scheme.
- Keilor Bus 1 66 kV fault levels could exceed the 21.9 kA limit under system normal conditions. AVP is working with AusNet Services, Jemena and Powercor to determine if this exceedance can be managed by increasing the fault level of the station to the limits included in the existing use of system agreement (UoSA) which are based on the actual ratings of the equipment in the station.
- Altona 66 kV fault levels are within planning limits. Powercor has identified equipment downstream with lower fault level capability and is investigating options to address the issue.

4.6.6 High voltage control at connection points

Control of high voltages in both transmission and distribution networks has been challenging during low/minimum demand periods, particularly with increased distributed PV generation relative to underlying demand. In December 2023, Victoria experienced a new minimum system load level of 1,564 MW that resulted in high voltage conditions on the 500 kV network[95].

In addition to low operational demand, reactive power injection from the distribution networks to the DSN has contributed to high DSN voltages that need to be carefully managed to stay within operational and design limits. In 2023-24, out of 32 terminal stations assessed, 28 terminal stations were found to be injecting reactive power for more than 10% of the year[96]. The new reactors at KTS and MLTS have reduced, but not entirely eliminated, the need for operational intervention to manage these high voltages.

AVP has been working closely with AEMO Operations in identifying and aiding in the development of a new Victorian system load voltage management strategy. As part of this strategy, during high voltage conditions the Keilor Over Voltage Protection Scheme (KTSOVPS) will be utilised.

AVP is currently conducting a Metropolitan Melbourne voltage management RIT-T; the investment is required to maintain Victorian DSN voltages in metropolitan Melbourne region within operational and design limits, during both maximum and minimum demand periods. The options considered in the RIT-T include the installation of additional reactive power support at 220 kV, which could address high voltage control issues at both transmission and distribution level. Refer to Section 3.1.5 for more information about this RIT-T.

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[95] More information is in the *Victorian Network Performance and Insights Report*, at https://aemo.com.au/energy-systems/electricity/national-electricity-market-nem/nem-forecasting-and-planning/victorian-planning/victorian-annual-planning-report.

[96] For more details, see Section 2.3.2 of the *Victorian Network Performance and Insights Report*, at https://aemo.com.au/energy-systems/electricity/national-electricity-market-nem/nem-forecasting-and-planning/victoian-planning/victorian-annual-planning-report.

4.6.7 Transmission connection planning

AVP reviews DNSP plans for existing and new connection points and incorporates the impact of any distribution network modifications in its transmission planning work. AVP and DNSPs work together to resolve connection asset limitations, and this cooperation ensures a co-optimised and efficient solution for both the distribution network and the DSN. **Table 20** includes information on constraints and augmentations identified in the 2023 Transmission Connection Planning Report[97] prepared by the Victorian DNSPs that are assumed to be implemented for the purpose of this Annual Planning Review.

Table 20 DNSP preferred connection modifications

Location/terminal station	Preferred connection modification	DNSP impacts and considerations
Altona – Brooklyn	Install an additional transformer capacity and reconfigure 66 kV exits at ATS or BLTS by 2029.	Increased demand requiring this transformer will be included in Greater Melbourne and Geelong planning.
Altona West (No. 3 and 4 buses) 66 kV	Install an additional 150 MVA 220/66 kV transformer and reconfigure 66 kV exits at ATS by 2029.	Increased demand requiring this transformer will be included in Greater Melbourne and Geelong planning.
Cranbourne 66 kV	Install a fourth Cranbourne 150 MVA 220/66 kV transformer by summer 2026-27, as determined by RIT-T.	Increased demand requiring this transformer will be included in Greater Melbourne and Geelong planning.
Deer Park 66 kV	Procure a dedicated spare 225 MVA 220/66 kV transformer by 2026.	Increased demand requiring this transformer will be included in Greater Melbourne and Geelong planning.
Glenrowan 66 kV	Additional embedded generation may justify additional 220/66 kV transformation capacity.	Monitoring embedded generation output levels will continue, as increased embedded generation will be considered in regional Victoria planning.
Keilor 66kV	Install an additional transformer capacity and transfer 66 kV exits at KTS B(1,2,5) to KTS B(3,4) by 2030 or earlier.	Increased demand requiring this transformer will be included in Greater Melbourne and Geelong planning.
Richmond 66kV	Install a fourth transformer at RTS 66 kV by 2030.	Increased demand requiring this transformer will be included in Greater Melbourne and Geelong planning.
South Morang 66 kV	Install a third South Morang 225 MVA 220/66 kV transformer by 2026.	Increased demand requiring this transformer will be included in Greater Melbourne and Geelong planning.
Wemen 66 kV	Additional embedded generation may justify additional 220/66 kV transformation capacity.	Monitoring embedded generation output levels will continue, as increased embedded generation will be considered in regional Victoria planning.

4.7 Proposed updates to the Transmission Development Plan

The 2024 VAPR outcomes including the network limitations are largely consistent with those reported in 2023 VAPR, except for two new priority limitations which are mainly driven by the changing supply mix in Victoria:

- Increased import from New South Wales at times of peak demand is driving a thermal limitation in the Eildon – Thomastown 220 kV line when the Rowville A1 500/220kV transformer is lost under contingency. It is

[97] At https://dapr.ausnetservices.com.au/ausnet_data/2023%20TCPR.pdf.

anticipated that the RIT-T for the Eastern Metropolitan area will address this limitation as it is already responding to other Rowville A1 transformer contingencies.

- Increased import from New South Wales at times of peak demand is driving a thermal limitation in the Red Cliffs – Wemen – Kerang 220 kV line. Network investment is likely to be required in the next decade to address this limitation.

The proposed updates in the Transmission Development Plan and next steps after the 2024 VAPR are:

1. Urgent delivery of the major augmentation projects that are already underway such as WRL, VNI West and RDP Stage 1 projects.
2. Progress with the ongoing RIT-Ts on Provision of System Strength and Metropolitan Melbourne Voltage Management to complete them and move them into delivery stage to meet the optimal delivery time.
3. Scope and progress with the recently commenced RIT-Ts for the East Victorian Grid Reinforcement and Western Metro Reinforcement projects to justify the investments and develop them into augmentation projects.
4. Commence pre-feasibility studies to investigate the newly identified Priority limitation in 2024 VAPR in Murray River REZ (as described in Section 4.2.2) to assess the need for investment. This will include:
   - Planning studies to identify the need in detail and quantify the need in relation to the risk associated with not addressing it.
   - Identifying options to address the need to maximise utilisation without causing exceedances.

A1. Approach to network limitation review

To identify network augmentation needs, AVP investigates transmission network limitations by:

- Reviewing historical network performance over the previous year, noting that past performance is becoming a weaker indicator of future performance as the demands on the DSN change[98].
- Reviewing future network performance under a range of demand and generation scenarios considering government policy and economic growth projections described in Section 2 and Section 3, through exploratory studies in this section.

For the purposes of the VAPR, a limitation is defined as a network element or location that, in the next 10 years:

- Is forecast to be loaded to 90% of its continuous rating of a DSN network element, or experience voltages outside its normal voltage range, during system normal operating conditions.
- Is forecast to be loaded to 90% of its short-term rating of a DSN network element, or experience voltages outside its contingency voltage range, following a credible contingency event.
- Does not maintain the minimum three phase fault level or stable voltage waveform system strength standard for that location as determined under by AEMO under NER 5.20C.1.
- Has voltage unbalance levels which do not meet the requirements outlined in NER 5.1a.7.
- Has typical inertia dispatched being less than the secure operating level of inertia, where the typical inertia is the value at one standard deviation below the mean and the secure operating level of inertia is the minimum level of inertia required to operate an islanded inertia sub-network in a secure operating state[99].
- Does not maintain sufficient reactive margins following a credible contingency event as outlined in NER 5.1.8.
- Does not meet the requirements for steady-state magnitude of power frequency voltage outlined in NER 5.1.4.
- Has a fault level shortfall as outlined in NER 11.143.14.
- Has a heavily restricted outage window due to other constraints and limitations.

Exploratory studies, which mainly include screening and trigger studies, are carried out to identify DSN thermal and voltage control limitations that may emerge over the next 10 years. Screening studies are used to identify expected limitations, while trigger studies are used to test the system under more extreme scenarios to identify conditions that trigger further limitations.

The VAPR analysis always incorporates a full set of state-wide screening studies, and specific trigger studies are undertaken if necessary to examine the triggers likely to cause transmission network limitations beyond the current 10-year forecasts of generation, demand, or other planning inputs.

[98] See Section 3 in the *Victorian Network Performance and Insights Report*, at https://aemo.com.au/energy-systems/electricity/national-electricity-market-nem/nem-forecasting-and-planning/victorian-planning/victorian-annual-planning-report.

[99] For more information, see *Inertia Requirements Methodology Inertia Requirements and Shortfalls*, at https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/System-Security-Market-Frameworks-Review/2018/Inertia_Requirements_Methodology_PUBLISHED.pdf.

Screening studies identify limitations by assessing network performance in terms of security and performance obligations under a range of different power system configurations. Security and performance obligations define the transmission system's technical limitations (for example, voltage ranges, thermal limits, stability limits, maximum fault currents, and fault clearance requirements). These obligations ensure that connected assets (and the power system itself) are designed to operate within known technical limits.

In assessing the impact of limitations, AVP considers information from power system performance analysis each year for the next 10 years regarding:

- The percentage n and n–1 loadings of transmission plant associated with the network loading limitation, based on the continuous and short-term ratings respectively.
- The load and energy at risk. Load at risk is the load shedding required to avoid the network limitation.
- Expected unserved energy (USE), which is the energy at risk after accounting for forced outages.
- Dispatch cost, which is the additional cost from constraining generation.
- Limitation cost, which is the total additional cost due to both constraining generators and expected USE.

Power system performance analysis uses conservative assumptions for demand, temperature, and wind speed to capture as many network limitations as possible for market simulation. For this reason, DSN performance analysis results (that is, the percentage loadings) can show more severe impacts than market simulations. AVP derives forecast transmission plant loadings using load flow simulations and develops load flow base cases for these simulations using inputs and assumptions aligned with AEMO's latest IASR wherever possible. Key assumptions and inputs include:

- The 10% POE terminal station demand for maximum demand base cases.
- Historical maximum power transfers for a high Victoria to New South Wales power transfer base case.
- Typical generation dispatch and interconnector flow patterns under the given operating conditions.
- The system normal operational configuration for the existing Victorian transmission network.
- Committed transmission network augmentation and generation projects, and other likely future projects which AVP considers relevant to network limitation review.
- Standard continuous ratings and short-term ratings at 45°C and 0.6 metres per second (m/s) wind speed.
- Unless indicated, 15-minute ratings for transmission lines. Some transmission lines in Victoria are equipped with automatic load shedding schemes, which avoid overloading by disconnecting load blocks following a contingency. These schemes allow lines to operate to 5-minute ratings.
- AVP bases the market impact of each network limitation on probabilistic market simulations that apply:
  - Weighted 50% POE and 10% POE maximum demand forecasts (weighted 70% and 30% respectively).
  - Historical wind generation availability, and historical load profiles.
  - Dynamic ratings based on historical temperature traces.
- Committed new and retired generation.

For more information, see the Victorian Electricity Planning Approach[100].

[100] At https://www.aemo.com.au/-/media/Files/Electricity/NEM/Planning_and_Forecasting/Victorian_Transmission/2016/Victorian-Electricity-Planning-Approach.pdf.

A2. DSN limitations detail

Details for transmission network limitations are grouped geographically in the following sub-sections.

Changes in the list of limitations from the 2023 VAPR are:

- Category changes:
  - Overload of Red Cliffs – Wemen – Kerang corridor due to increased flow at maximum demand times following completion of the EnergyConnect project. This limitation has upgraded from monitored limitation and is now considered a priority limitation, as outlined in Section 4.2.
  - Overload of Eildon – Thomastown 220 kV line for trip of Rowville A1 500/220 kV transformer. This limitation has been upgraded from monitored limitation and is a now considered a priority limitation, as outlined in Section 4.2.
- New limitations:
  - Overload of Dederang – Wodonga 330 kV line loading during high demand/import and during high export for the contingency trip of a Dederang – Murray 220 kV line. This limitation is now considered to be monitored.
- Removed limitations:
  - Legacy limitation types 'priority', 'emerging' and 'developing' have all been removed, with all these types of limitations migrated to 'priority'.

The possible network solutions presented in the sub-sections below should be treated as indicative only, and a RIT-T will be required to determine the full list of network and non-network options as well as the preferred option. The preferred option may include one or a combination of the solutions presented in the sub-sections below.

In this appendix, triggers are defined as the operating conditions under which a limitation may result in supply disruptions or constrain generation at increased frequency. A trigger being met will not necessarily result in any augmentations being justified, as that would be subjected to a RIT-T or appropriate consideration.

A2.1 Central North REZ

Table 21 Limitations in the Central North REZ

Limitation	Limitation type	Possible network solution	Trigger	2024 ISP/2023 NSCAS	Contestable project status
Dederang – Glenrowan – Shepparton – Bendigo 220 kV **and** **Dederang – Shepparton 220 kV line loading**	Monitored	• Install an automatic load shedding and generation runback control scheme to enable the use of five-minute line rating. • Install a wind monitoring scheme. • Install a modular flow controller on the Bendigo – Fosterville – Shepparton 220 kV line. • Replace existing Dederang – Shepparton and Shepparton – Bendigo 220 kV line with new double circuit lines.	Increased demand in regional Victoria and/or increased import from New South Wales. Large-scale new generation connected to Western Victoria and Central North areas, and congestion within Western Victoria relieved to allow the new generation to be sent out of Western Victoria.	Identified limitation as part of Central North Victoria REZ.	Any new transformer or new transmission lines are likely to be contestable projects.

A2.2 Eastern Corridor

Table 22 Limitations in the Eastern Corridor

Limitation	Limitation type	Possible network solution	Trigger	2024 ISP/2023 NSCAS	Contestable project status
Thermal limitations in Latrobe Valley 220 kV corridor – Overloading Hazelwood to Yallourn to Rowville220 kV lines post Yallourn retirement.	Priority	• AVP has identified a new switching arrangement at HWPS (modified parallel mode) for post YWPS retirement to utilise the eastern 220 kV corridor. • AVP has initiated a minor augmentation project to scope out the details of the works required to facilitate the proposed re-configuration in year 2028. The scope includes minor switching works at HWPS and implementation of a control scheme to manage post contingent overloading.	Decommissioning of YWPS with modified parallel mode or additional generation is commissioned on the 220 kV network at HWPS, at a site east of HWPS, or on the 500 kV network east of Cranbourne Terminal Station (CBTS).	Not identified.	Works to reconfigure HWPS are unlikely to be contestable.
Hazelwood – Loy Yang 500 kV line loading	Monitored	• Construct a new single circuit Hazelwood – Loy Yang 500 kV line. • Construct a new double circuit Hazelwood – Loy Yang 500 kV and string only one circuit.	Commissioning of additional generation connected at LYPS.	Identified in 2020 ISP.	Any new line is likely to be competitively sourced.

Limitation	Limitation type	Possible network solution	Trigger	2024 ISP/2023 NSCAS	Contestable project status
		• Construct a new double circuit Hazelwood – Loy Yang 500 kV and string both.			
Hazelwood – Loy Yang 500 kV line outage window	Monitored	• Construct a new single circuit Hazelwood – Loy Yang 500 kV line. • Construct a new double circuit Hazelwood – Loy Yang 500 kV and string only one circuit. • Construct a new double circuit Hazelwood – Loy Yang 500 kV and string both. • System strength and reactive power services to reduce reliance on Loy Yang units for these services during low demand periods.	Reduction in dispatchable capacity west of Hazelwood 500 kV. Higher and more frequent demands above 6,000 MW.	Not identified.	Any new line is likely to be competitively sourced.

A2.3 Northern Corridor

Table 23 Limitations in the Northern Corridor

Limitation	Limitation type	Possible network solution	Trigger	2024 ISP/2023 NSCAS	Contestable project status
Dederang – Mount Beauty 220 kV line loading	Monitored	• Install wind monitoring scheme. • Up-rate the conductor temperature of both 220 kV circuits between Dederang and Mount Beauty to 82°C.	Increased demand in Metropolitan Melbourne or increased export to New South Wales with high hydro generation in the area.	Not identified as a material limitation in the scenarios modelled.	If needed, these are unlikely to be contestable projects.
Mount Beauty – Eildon 220 kV line loading	Monitored	• Install wind monitoring scheme. • Up-rate Mount Beauty – Eildon – Thomastown 220 kV line, including terminations to 75°C operation.	Increased New South Wales import and export.	Not identified as a material limitation in the scenarios modelled.	If needed, this is unlikely to be a contestable project.
Eildon – Thomastown 220 kV line loading	Priority	• Install wind monitoring scheme. • Up-rate Eildon – Thomastown 220 kV line, including terminations to 75°C operation. • Complete Eastern Metro RIT-T works which will remove trigger.	Loss of Rowville A1 transformer at times of high demand in Eastern Metropolitan Melbourne.	Not identified as a material limitation in the scenarios modelled.	Wind monitoring or line up-rating are unlikely to be contestable projects.

Limitation	Limitation type	Possible network solution	Trigger	2024 ISP/2023 NSCAS	Contestable project status
Dederang 330/220 kV transformer loading	Monitored	• Install a fourth 330/220 kV transformer at Dederang (or a newly established station nearby).	At times of over 2,500 MW of imports from New South Wales and Murray generation (with the DBUSS transformer control scheme being active).	Not identified as a material limitation in the scenarios modelled.	Any new transformer is likely to be a contestable project.
Voltage stability at North Victoria/South New South Wales (import)	Monitored	• Procure network support services, including the provision of additional reactive support (generating). • Install additional capacitor banks and/or controlled series compensation at Dederang and Wodonga terminal stations.	Increased import from New South Wales to Victoria (high demand in Victoria).	Not identified as a material limitation in the scenarios modelled.	If needed, these are both likely to be contestable projects
Voltage stability at North Victoria/South New South Wales (export)	Monitored	• Procure network support services. • Install an SVC or a Static Compensator (STATCOM).	Increased export to New South Wales from Victoria under minimum demand in Victoria.	Constraint identified during high export to New South Wales.	If needed, these are both likely to be contestable projects.
Murray – Dederang 330 kV line loading	Monitored	• Install third 1,060 MVA 330 kV line between Murray and Dederang (or a newly established station nearby). • Install second 330 kV line from Dederang (or a newly established station nearby) to Jindera. • Rebuild sections of VNI East interconnector at 500 kV.	Increased import from New South Wales to Victoria or Murray generation.	Not identified as a material limitation in the scenarios modelled.	If needed, these are both likely to be contestable projects.
Dederang – Wodonga 330 kV line loading (high demand/ import)	Monitored	• Install wind monitoring scheme. • Up-rate Dederang – Wodonga 330 kV line, including terminations.	Loss of a Dederang to Murray 330 kV line.	Not identified as a material limitation in the scenarios modelled.	If needed, this is unlikely to be a contestable project.
Dederang – Wodonga 330 kV line loading (export)	Monitored	• Install wind monitoring scheme. • Up-rate Dederang – Wodonga 330 kV line, including terminations.	Loss of a Dederang to Murray 330 kV line.	Not identified as a material limitation in the scenarios modelled.	If needed, this is unlikely to be a contestable project.

A2.4 Murray River REZ

Table 24 Limitations in the Murray River REZ

Limitation	Limitation type	Possible network solution	Trigger	2024 ISP/2023 NSCAS	Contestable project status
Voltage oscillation in western and north-west Victoria (under prior outage)	Monitored	• Non-market ancillary services (NMAS) contracts to provide system strength. • Install automatic generation runback control schemes.	Increased probability of prior outages of local 220 kV transmission lines. Reduced system strength in the region.	Constraint identified during high solar generation and prior outage.	Any solutions are likely to be contestable projects.
Red Cliffs – Wemen – Kerang – Bendigo 220 kV line loading (high generation or high demand)	Monitored	• Replace the existing Bendigo – Kerang – Wemen – Red Cliffs 220 kV line with a new double circuit 220 kV circuit line and establish associated new terminal stations or existing station augmentations.	Increased generation in regional Victoria.	Identified as limitation as part of Murray River REZ.	Any solutions are likely to be contestable projects.
		• Install an automatic load shedding control scheme to enable the use of five minute line rating. • Replace the existing Bendigo – Kerang – Wemen – Red Cliffs 220 kV line with a new double circuit 220 kV circuit line and establish associated new terminal stations or existing station augmentations.	Increased demand in regional Victoria.	Not identified as limitation as it is a localised issue.	
Red Cliffs – Wemen – Kerang 220 kV line loading (high Victorian demand)	Priority	• Building a second Red Cliffs – Wemen - Kerang 220 kV line by either building a new single circuit or building a new double circuit and retiring the existing line. • Installing a Power Flow Controller (or similar device) on the Red Cliffs – Wemen – Kerang 220 kV line to divert flow away from the line at times of high demand. • Installing a protection scheme to run back generators to limit the flow from Victorian generators and generators supplying into Red Cliffs from New South Wales.	High Victorian demand post the commissioning of EnergyConnect and retirement of YWPS.	Identified as limitation as part of Murray River REZ.	Protection scheme or power flow controller works are unlikely to be contestable projects.
Voltage instability/collapse in North West Victoria (around Wemen Terminal Station)	Monitored	• NMAS contract for the use of spare reactive power capacity. • Install dynamic voltage regulation such as SVC.	Low local demand and high solar generation.	Not identified as a limitation as it is a localised issue.	Any solutions are likely to be contestable projects.

A2.5 South West Victoria REZ

Table 25 Limitations in the South West Victoria REZ

Limitation	Limitation type	Possible network solution	Trigger	2024 ISP/2023 NSCAS	Contestable project status
Ballarat – Berrybank – Terang – Moorabool 220 kV line loading	Monitored	• Install automatic generation runback control schemes. • Replace the existing Ballarat – Berrybank – Terang – Moorabool 220 kV line with a new double circuit 220 kV circuit line.	Increased generation in regional Victoria.	Identified as limitation as part of South West Victoria REZ.	Solutions are likely to be contestable projects.
Moorabool – Heywood – Portland 500 kV line voltage unbalance	Monitored	• A switched capacitor with individual phase switching at Heywood or near Alcoa Portland. • Install phase switched power flow controllers at Heywood or near Alcoa Portland. • An SVC or a STATCOM. • Additional transposition towers along the Moorabool – Heywood – Alcoa Portland 500 kV line.	New generation connections along the Moorabool – Heywood – Alcoa Portland 500 kV line potentially introduce voltage unbalance along the line. The impact of voltage unbalance levels increases in proportion to power flow, new generation connection points, and output generated.	Limitation not found as part of 2022 ISP/2022 NSCAS as it is related to voltage quality.	Switched capacitor and static MVAr options are likely to be contestable projects. Line transposition is unlikely to be a contestable project.
Inadequate south-west Melbourne 500 kV thermal capacity	Monitored	• A new Moorabool – Mortlake/Tarrone – Heywood 500 kV line. • Line limiting plant upgrades. • Install wind monitoring dynamic line rating scheme.	Significant wind generation and/or gas generation (in addition to the existing generation from Mortlake) is connected to the transmission network in the South-West Corridor.	Identified as a limitation in 2020 ISP South West Victoria REZ Scorecard.	Any new line is likely to be a contestable project.
Moorabool 500/220 kV transformer loading	Monitored	• Transformer limiting plant upgrade. • Install an automatic generation runback control scheme. • Install third Moorabool 500/220 kV transformer.	Large-scale new generation connected to western Victoria area, and congestion in western Victoria relieved to allow the new generation to be sent out of western Victoria.	Not identified as a material limitation in the scenarios modelled.	Any new transformer is likely to be a contestable project.

A2.6 Greater Melbourne and Geelong

Table 26 Limitations in Greater Melbourne and Geelong

Limitation	Limitation type	Possible network solution	Trigger	2024 ISP/2023 NSCAS	Contestable project status
Ringwood – Thomastown 220 kV line loading	Priority	Two options currently being assessed as part of East Metro RIT-T: • Option 1 – Install transformer at Rowville and perform line overload and fault level mitigation works. – Bringing forward VNI West works to address Eildon – Thomastown 220 kV line overloads. – Installing a third 500/220 kV transformer at Rowville to provide backup to the existing A1 transformer providing supply to the Rowville 220 kV No.3/4 220kV bus. – Cutting the existing lines between Rowville and Thomastown into Ringwood and Templestowe and then operate the lines between Ringwood and Templestowe as normally open (to reduce fault levels). – Equipment replacements at stations that have fault level exceedances. • Option 2 – Install transformer at Cranbourne and perform line overload and fault level mitigation works. – Bringing forward VNI West works to address Eildon – Thomastown 220 kV line overloads. – Transferring the Rowville A2 transformer to Rowville 220 kV bus 34 to back up the A1 transformer. – Installing a second 500/220 kV transformer at Cranbourne to provide backup to the existing transformer and provide supply to the Rowville 220 kV bus 12. – Cutting the existing lines between Rowville and Thomastown into Ringwood and Templestowe and then operate the lines between Ringwood and Templestowe as normally open (to reduce fault levels). – Equipment replacements at stations that have fault level exceedances.	Increased demand in eastern metropolitan Melbourne. Reduced supply from Eastern Victoria and increased supply from Western Victoria.	Not identified as it is a localised issue.	Any line cut-in is unlikely to be a contestable project. Any new transformer is likely to be a contestable project.
Templestowe – Thomastown 220 kV line loading	Monitored				
Rowville A1 500/220 kV transformer loading	Priority				

Limitation	Limitation type	Possible network solution	Trigger	2024 ISP/2023 NSCAS	Contestable project status
Rowville – Malvern 220 kV line loading	Monitored	• Cut-in Rowville – Richmond 220 kV No. 1 and No. 4 circuits at Malvern Terminal Station to form the Rowville – Malvern – Richmond No. 3 and No. 4 circuits.	Increased demand or additional loads connected to Malvern Terminal Station.	Not identified as it is a localised issue.	Any line cut-in is unlikely to be a contestable project.
Rowville – Springvale – Heatherton 220 kV line loading[101]	Monitored	• Connect a third Rowville –Springvale circuit (underground cable). • Connect a Cranbourne – Heatherton 220 kV double circuit overhead line.	Increased demand or additional loads connected to Springvale and Heatherton Terminal Station.	Not identified as it is a localised issue.	If needed, the third circuit is likely to be a contestable project.
South Morang H1 330/220 kV transformer loading	Monitored	• Replace the existing transformer with a higher rated unit in conjunction with AusNet Services asset replacement program.	Increased demand in Metropolitan Melbourne and/or increased import from New South Wales.	Not identified as a material limitation in the scenarios modelled.	This is unlikely to be a contestable project.
Cranbourne A1 500/220 kV transformer loading	Monitored	• Install a new 500/220 kV 1,000 MVA transformer at Cranbourne Terminal Station and cut in the existing Hazelwood – Rowville No.3 500 kV line at Cranbourne.	Increased demand around the Eastern Melbourne Metropolitan area. Reduced supply in the 220 kV metro network and increased supply from the 500 kV network.	Not identified as a material limitation in the scenarios modelled.	Any line cut-in is unlikely to be a contestable project. The new transformer is likely to be a contestable project.
South Morang – Thomastown No. 1 and No. 2 220 kV line loading	Monitored	Increase the transfer capability by installing wind monitoring facilities on the South Morang to Thomastown line. Install an automatic load shedding control scheme to enable the use of five-minute line rating. Install a third 500/220 kV 1,000 MVA transformer at Rowville, plus any fault level mitigation works.	Increased demand around the Melbourne Metropolitan area and/or increased export to New South Wales. Generation planting and retirements as per the 2022 ISP *Step Change* scenario.	Not identified as it is a localised issue.	Any new transformer is likely to be a contestable project.
Moorabool – Geelong 220 kV line loading	Priority	Three options currently being assessed as part of West Metro RIT-T: • Option 1 – Deer Park cut in with Moorabool to Geelong uprate. – Cut Geelong – Keilor #1 and #3 220 kV lines into Deer Park. – Perform works to increase line rating of existing Geelong – Moorabool 220 kV lines (replace limiting plant, install SOCS scheme and wind monitoring).	Large-scale new generation connected to western Victoria area, and congestion within western Victoria relieved to allow the new generation to be sent out of western Victoria. Generation planting and retirements as per the 2022 ISP *Step Change* scenario.	Not identified as a material limitation in the scenarios modelled.	Any line cut-in is unlikely to be a contestable project. The new transformer is likely to be a contestable project.
Geelong – Keilor 220 kV line loading	Priority				
Keilor – Deer Park – Geelong 220 kV line loading	Priority				

101 These monitored limitations assume five-minute ratings are already applied. An automatic load shedding control scheme to enable five-minute line ratings is currently available to manage this limitation.

Limitation	Limitation type	Possible network solution	Trigger	2024 ISP/2023 NSCAS	Contestable project status
		– Under this arrangement Deer Park would be decoupled from Keilor and supplied from Geelong. • Option 2 – Deer Park cut in with Moorabool to Geelong third circuit. – Cut Geelong – Keilor #1 and #3 220 kV lines into Deer Park. – Construct a third Geelong – Moorabool 220 kV line. – Under this arrangement Deer Park would be decoupled from Keilor and supplied from Geelong. • Option 3 – Establish Truganina Terminal Station. – Construct new 500/220 kV Truganina TS cutting into the existing Moorabool – Sydenham 500 kV lines and build 220 kV lines from Truganina to Deer Park. – Additionally works are required to bond existing Geelong – Keilor and Deer Park – Keilor 220 kV lines together to create a high-capacity connection between Deer Park and Keilor.	Increased maximum demand in Metropolitan Melbourne.		
Keilor – Thomastown No. 1 220 kV line loading	Monitored	• Increase the transfer capability by installing wind monitoring facilities on the Keilor to Thomastown line. • Install an automatic load shedding control scheme to enable the use of five-minute line rating • Install a third 500/220 kV 1,000 MVA transformer at Rowville, plus any fault level mitigation works.	Reduced supply from Eastern Victoria and increased supply from Western Victoria.	Not identified as it is a localised issue.	The new transformer is likely to be a contestable project.
Sydenham – Keilor 500 kV line loading	Monitored	• Line limiting plant upgrades at Sydenham and Keilor terminal stations. • Install a new single circuit Sydenham – Keilor 500 kV line with a rating of approximately 2,900 MVA at 35°C. • Uprate line rating of the existing 500 kV SYTS–KTS.	Increased generation in west and south-west Victoria supplying KTS.	Not identified as a material limitation in the scenarios modelled.	The new line is likely to be a contestable project.

A2.7 Western Victoria REZ

Table 27 Limitations in Western Victoria REZ

Limitation	Limitation type	Possible network solution	Trigger	2024 ISP/2023 NSCAS	Contestable project status
Red Cliffs – Kiamal – Murra Warra – Horsham – Bulgana 220 kV line	Monitored	• Install automatic generation runback control schemes. • Install a new double circuit Bulgana to Murra Warra 220 kV line via a new terminal station at Horsham.	Increased generation in Western Victoria and Murray River REZ.	Not identified.	These are unlikely to be contestable projects.
Inadequate reactive power support in Regional Victoria	Monitored	• Staged installation of additional reactive power support in Regional Victoria.	Increased maximum demand and/or reactive power consumption in regional Victoria.	2022 ISP/NSCAS did not identify this limitation as it is a localised issue.	Additional reactive support is unlikely to be a contestable project.

A2.8 Victoria system-wide

Table 28 Limitations in the Victorian system

Limitation	Limitation type	Possible network solution	Trigger	2024 ISP/2023 NSCAS	Contestable project status
Insufficient demand to dispatch system strength services from synchronous generation	Monitored	• Install synchronous condensers at strategic locations of the network. • Install grid-forming BESS. • Contract synchronous generation to provide system strength services.	Decreasing minimum demand	2024 ISP/2023 NSCAS did not identify this limitation	This is likely to be a contestable project.

A3. System strength supporting publications

AEMO's annual System Strength Report is based on two core publications:

- The System Strength Requirements Methodology.
- The System Strength Impact Assessment Guidelines (SSIAG).

The System Strength Requirements Methodology was published by AEMO on 26 September 2022, with an effective date of 1 December 2022, and provides the process AEMO uses to determine the system strength requirements for each NEM region, including:

- Determination of system strength nodes.
- Modelling performed to determine the nodes and three-phase fault levels and system strength requirements.
- Criteria for stable voltage waveform services.
- Assumptions underpinning the basis for inputs.

The updated SSIAG (version 2.2) was published on 28 June 2024, with an effective date of 1 July 2024[102], and is a valuable resource for proponents connecting to the power system, describing the assessment process and methodology for:

- Undertaking system strength impact assessments.
- Calculating system strength locational factor (SSLF).
- Calculating available fault levels (AFLs).
- Assessing the short circuit ratio (SCR) for the purposes of SCR access standards.
- Demonstrating compliance with relevant performance standards.
- The criteria for classification as an IBL, IBR and large inverter-based resource (LIBR).
- Verifying the stability of the plant.

The System Strength Unit Price (SSUP) is the price (in $/MVA/year) that applies to generators choosing not to self-remediate their system strength impact on the network. This price is calculated uniquely at each system strength node every five years and captures the long-run costs of a SSSP procuring the system strength services when supporting the connection of a new project. The latest schedule of prices, for the charging period 1 July 2023 to 1 July 2028, was released in August 2024 as part of the Amended Shared Transmission Network Services Prices in Victoria – 1 July 2024 to 30 June 2025[103].

[102] At https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2024/ssiag/system-strength-impact-assessment-guidelines-v22.pdf.

[103] At https://www.aemo.com.au/energy-systems/electricity/national-electricity-market-nem/participate-in-the-market/fees-and-charges.

Abbreviations

Abbreviation	Term
AEMC	Australian Energy Market Commission
AEMO	Australian Energy Market Operator
AFL	available fault level
APD	Alcoa Portland
APDICS	Alcoa Portland Inter-trip Control Scheme
ARPS	Anti Resonance Protection Scheme
AVP	AEMO Victoria Planning
BESS	battery energy storage system/s
BGTS	Bulgana Terminal Station
BMM	Business Mass Market
CB	circuit breaker
CBTS	Cranbourne Terminal Station
CER	consumer energy resources
DC	direct current
DDTS	Dederang Terminal Station
DEECA	Department of Energy, Environment and Climate Action
DNSP	distribution network service provider
DSN	Declared Shared Network
DSTO	Declared Transmission System Operator
EAPT	Emergency Alcoa Potline Trip
EES	Environmental Effects Statement
ESOO	*Electricity Statement of Opportunities*
EV	electric vehicle
FID	Final Investment Decision
GIL	Gas Insulated Line
GIS	Gas Insulated Switchgear
GPSRR	*General Power System Risk Review*
GTS	Geelong Terminal Station
GW	gigawatt/s
HIC	Heywood Interconnector
HVDC	high voltage direct current
HWTS	Hazelwood Terminal Station
HYTS	Heywood Terminal Station
IBL	inverter-based load
IBR	inverter-based resources
ISP	*Integrated System Plan*
JPB	Jurisdictional Planning Body

Abbreviation	Term
kA	kiloampere
KESS	Koorangie Energy Storage System
KTS	Keilor Terminal Station
KTSOVPS	Keilor Terminal Station Over Voltage Protection Scheme
kV	kilovolt/s
LIBR	large inverter-based resource
LIL	large industrial load
LYPS	Loy Yang Power Station
MLTS	Moorabool Terminal Station
MSL	Minimum System Load
MSS	Murray Switching Station
MVA	megavolt ampere/s
MVAr	megavolt ampere/s reactive
MW	megawatt/s
MWH	megawatt Hour/s
NEM	National Energy Market
NER	National Electricity Rules
NEVA	*National Electricity (Victoria) Act 2005*
NOAC	Normally Open Auto-Close
NPV	net present value
NSCAS	network support and control ancillary services
NVES	New Vehicle Efficiency Standard
OVPS	Over Voltage Protection Scheme
PACR	Project Assessment Conclusions Report
PADR	Project Assessment Draft Report
POE	probability of exceedance
PSCR	Project Specification Consultation Report
PSFRR	*Power System Frequency Risk Review*
PV	photovoltaic
RDP	Renewable Energy Zone (REZ) Development Plan
REZ	renewable energy zone
RIT-T	regulatory investment test for transmission
ROTS	Rowville Terminal Station
SAIT RAS	South Australia Interconnector Trip Remedial Action Scheme
SCR	short circuit ratio
SEC	State Electricity Commission
SMTS	South Morang Terminal Station
SOCS	System Overload Control Scheme
SSC	System Strength Charge
SSIAG	System Strength Impact Assessment Guidelines

Abbreviation	Term
SSLF	System Strength Locational Factor
SSSP	System Strength Service Provider
SSUP	System Strength Unit Price
STATCOM	Static compensator
SW500 GFT	South West 500 kV Generation Fast Tripping
SYTS	Sydenham Terminal Station
TAPR	Transmission Annual Planning Report
TCV	Transmission Company Victoria
TNSP	transmission network service provider
TS	terminal station
UoSA	Use of System Agreement
USE	unserved energy
VAPR	*Victorian Annual Planning Report*
VFRB	Very Fast Run Back
VNI West	Victoria – New South Wales Interconnector West
VNPIR	*Victorian Network Performance and Insights Report*
VPP	virtual power plant
VRE	variable renewable energy
VRET	Victorian Renewable Energy Target
VSAT	Voltage Stability Assessment Tool
VTIF	Victorian Transmission Investment Framework
VTP	Victorian Transmission Plan
WRL	Western Renewables Link
YWPS	Yallourn West Power Station