Victoria's energy transition risks and mitigation actions

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Executive summary

The Victorian Government has committed to reducing greenhouse gas emissions to net zero by 2045 to contribute to the global effort to avoid the worst impacts of climate change. Alongside this, the government has set ambitious renewable electricity targets of 65% by 2030, increasing to 95% by 2035 (DEECA, 2024b).

The electricity sector lies at the heart of Victoria's transition to a low emissions economy. Electricity is the largest emitting sector in Victoria, and it is already undergoing a process of transformation as renewable energy is built to replace the historic reliance on thermal generation (including brown coal), and as thermal assets age, become less reliable and require replacement with new technology. The electricity sector is also the key mechanism by which the next two largest emitting sectors (aside from agriculture), transport and direct combustion, can be decarbonised.

The energy transition is complex and involves a diverse range of stakeholders, including the government, agencies, industry and consumers. This presents challenges that will influence the pace and success of the state's shift towards renewable energy, and there are potential impacts on emissions, affordability, reliability, long-term security of supply and social equity.

The purpose of this project is to support Infrastructure Victoria in developing appropriate recommendations to include in the 2025 update to Victoria's 30-year Infrastructure Strategy with regards to Victoria's planned energy transition. This report presents evidence-based, independent analysis and advice on:

- Key risks to achieving Victoria's planned energy transition up to 2030 and 2035 and their potential consequences.
- The actions, strategies and/or measures the Victorian Government can take to mitigate or minimise these risks to achieving the energy transition.

Key risks

The identification of risks was informed by a review of existing plans and roadmaps, including the Australian Energy Market Operator's Integrated System Plan (Draft, 2024). A progress analysis identified risks based on current and projected gaps in infrastructure against what is existing, planned and needed, focusing on electricity infrastructure needs up to 2030 and 2035. The analysis reviewed current programs and investment schemes which cover all three of the major emissions sectors in Victoria covered in this report: electricity, direct combustion (including fossil gas) and transportation.

Key programs assessed cover the spectrum of reforms and programs designed to transition Victoria's energy sector. They include the Victorian Renewable Energy Target and energy storage targets for 2030 and 2035, the Victorian Offshore wind development program, the Victorian Energy Upgrades program, the Gas Substitution Roadmap and the Zero Emissions Vehicle Roadmap.

Risks were identified, analysed and rated considering their impact on energy objectives (emissions; security, reliability and safety; affordability; and social equity) using research, stakeholder engagement and the use of established models Sectoral Emissions and Abatement Model (SEAM) and PLEXOS, an energy market simulation engine.

Risk causes

Risk events identified have a wide variety of possible causes. In most cases, a risk event will have more than one potential cause. Community acceptance, technology, supply chain constraints (including the availability of a skilled workforce) followed closely by issues of investment appetite and economics, were identified as the most common causes of risks to the energy transition. Community acceptance, for example, can have a major influence on major infrastructure project delivery. Technological factors may include the engineering design complexity associated with large infrastructure delivery.

Issues around investment and economics affect most of the very high rated risks and cover the provision of capital investment for major projects through to decisions made at the household level on energy efficiency upgrades, including embedded battery storage and the installation of electric appliances to replace their gas equivalents. Prevailing economic conditions may have a bearing on the provision of capital for major projects at different times, potentially delaying projects or impacting the scale of developments. Economic conditions may also impact investment decisions at the household level.

A total of forty-seven (47) risks to Victoria's energy transition have been identified with eighteen (18) of these identified as very high or high. The key risks cluster around four themes:

Transition off coal. The biggest changes required in Victoria's energy system to drive the path to a low-carbon future carry the greatest number of very high and high risks. The SEAM modelling identified changes in brown coal generation retirement dates as having the largest overall impact on the achievement of Victorian emissions objectives in 2035. There are also significant risks to the energy transition associated with the development of variable renewable energy resources (including both offshore and onshore wind), with timely delivery of major transmission projects, and with developing dispatchable resources, such as long duration storage. Delays in delivering these major projects also threaten the affordability and reliability of energy supply in the period leading up to 2035.

Transition consumers off gas. Electrification plays a significant role in Victoria's future and many of the risks associated with electrification can be linked to decisions at the household or business level. The progress analysis highlights the task that lies ahead for Victoria in electrifying a large portion of its gas load before 2035, given the lifecycle of gas devices, and the required conversion rate needed to meet electrification goals. There is a very high risk that existing gas customers are not sufficiently incentivised to switch to electric alternatives at the rate required.

Transition consumers' use of energy. There is a risk that households do not improve the energy efficiency of their homes as much as projected. A social equity impact of this is energy poverty which disproportionately affects vulnerable populations, including low-income households and the elderly, with those least able to invest in energy efficiency subject to higher energy costs as a result. There is also a risk of a lack of customer take-up of embedded and aggregated storage to help manage the growing load on distribution networks in a future with greater amounts of rooftop PV, greater degrees of electrification, more electric vehicles on the road and more extreme peak demand as a consequence of climate change. This would potentially mean a higher cost at the network level to integrate more electric devices and more EVs into the electricity grid.

Transition vehicle fleet. There is a very high risk that consumer uptake of low- and zero-emissions vehicles is not rapid enough to achieve emissions objectives. This also has affordability and social equity implications if electric vehicles remain unaffordable for certain demographics or geographic regions.

Risk interconnections

There are important interconnections within and between the four key risk themes. For example, there are several key risks that influence the retirement of brown coal generation on schedule, including the development of new renewable generation and long duration storage options in time for coal's exit. Of note also is the high risk identified of inadequate management of additional loads and flows on distribution network, as electricity distribution networks play a central role in facilitating the transition off coal, off fossil gas, with the transition of customers use of energy and the transition of the vehicle fleet to electric.

Additionally, assuming gas fired thermal generation continues to play a key role in providing flexible firming power out to 2050, risk events that lead to greater usage of gas have a consequent impact on emissions in the national energy market. These risk events include the variability of demand due to extreme weather, issues with the reliability of other thermal plants and changes in load over time that add to peaking electricity load.

Additional risk considerations

Environmental, social and governance considerations were considered during this risk assessment. Of particular note is the inherent conflict between the need to build new infrastructure versus ongoing protection of biodiversity, ecological and social values. This conflict is a key driver affecting community acceptance of energy infrastructure projects, which is noted as a common cause of several key risks.

Energy equity, as articulated by the Australian Energy Regulator (2022), focuses on ensuring that the energy market is inclusive for all consumers, does not create or compound harms and barriers to participation, and provides affordable energy. Inadequate energy policies can perpetuate social inequities, as those who can least afford high energy costs bear the brunt of being unable to invest in electrification or energy efficiency. Following this, inadequate energy efficiency can directly affect residents' health and well-being. Poor insulation, inadequate heating, or lack of cooling can lead to uncomfortable living conditions, exacerbate existing health conditions, and impact mental health.

Also highlighted is the First Nations support for and partnership in the clean energy transformation as a key priority under the National Energy Transformation Partnership. Development of the First Nations Clean Energy Strategy is underway (as of April 2024) and will include ensuring First Nations self-determining rights, perspectives, views and decision-making are integrated into energy and climate change policy making and program development in Australia. Also noted is Victoria's commitment to Treaty, which advances Aboriginal self-determination (Department of Premier and Cabinet, Treaty for Victoria) which needs to be considered in the development of all policies and programs associated with the energy transition.

Mitigation actions

Mitigation actions can either reduce the likelihood of a risk occurring or reduce the impacts when it does occur. This analysis has sought to identify actions the Victorian government could take now to help manage the highest risks to the transition.

The actions presented are those qualitatively assessed as having the potential for the highest impact. These are directed at gaps in current policies or programs versus the rate of change required, or where the challenge is such that additional effort is needed now to help the state reach its goals. The actions cut across policy and regulation, planning and approvals, investment and innovation, consumer incentives, behaviour change, supply chain management and workforce planning. The key mitigation actions identified cluster around the four key risk themes.

Key insights on the high impact mitigation actions include:

- Key risks in the timely transition away from coal are best managed through continued implementation of the Victorian Renewable Energy Targets through new auctions, through new capacity underwritten by the Capacity Investment Scheme, and the development or facilitation of long duration storage.

- Risks in the transition off fossil gas are best managed through a clear plan of action for consumer electrification and communication with the wider Victorian public on the goals, the benefits, and the role to be played by Victorian consumers.

- Actions to encourage consumer adoption of embedded storage technology in greater numbers and to allow for more centralised or coordinated management of these resources will help to mitigate the risk that these resources fall short of what is needed in a future system with greater demand and more variable demand and generation.

- Risks in the transport sector are best managed through the establishment of higher targets for EV uptake, combined with incentives (to complement programs implemented by the Australian Government), that allow for the growth in the overall car fleet in Victoria noting that emissions reductions opportunities in the Victorian transport fleet must be seized early for Victoria to meet its wider emissions objectives by 2035.

- Common risk causes across major infrastructure delivery, electrification and consumer energy use are community acceptance and consumer behaviour. Continued focus and effort in community communication and education actions are therefore critical to drive support and ensure that the community understand the criticality of their participation and investment in their energy future. Effective implementation of communication protocols on relevant infrastructure projects to build community acceptance in affected communities is also vital.
- Another common risk cause is the availability of a skilled workforce to deliver major infrastructure projects and support consumers in the transition. As such, implementation of a comprehensive workforce investment plan that considers future-focused training programs, apprenticeships and finance to help re-skill the workforce for a renewable electric future is important.

Even if all of the proposed mitigation measures are applied, residual risks will still remain. For example, with large infrastructure projects, the scale of the developments and the unique challenges involved in building these assets mean that even after implementing the mitigations summarised in this report, some level of risk of project delay will remain. Measures are outlined to respond to the increasing impact of extreme weather events on reliability, however the severity and duration of these events cannot be known fully in advance. Increases in coal-fired power outages are in part outside the control of the Victorian Government as outages may occur in other regions of the National Electricity Market. Mitigating measures in other regions to deal with those outages, or lack thereof, will have an impact on Victorian consumers. Supply chain risks remain, for example the wider availability of electric vehicles and associated infrastructure on the timeframe and scale required. The risk also remains that there are inequitable outcomes from this transition. Gas network costs for gas consumers remaining on the gas network will likely increase as gas usage declines, and while these costs could be managed through bill support for vulnerable or critical customers, the risk of higher costs across a shrinking customer base remains.

ⓘ *Important note about this report*

This assessment is undertaken for:

- Infrastructure Victoria

The assessment is in accordance with the scope of services set out in the contract between Jacobs and Infrastructure Victoria. The purpose of this assessment is to undertake a review of Victoria's planned energy transition to a low emissions economy, including its risks, current delivery, timing, sequencing and risk mitigation actions. The work focuses on mitigation actions the Victorian Government could take between 2025 and 2030, and between 2030 and 2035.

In preparing this report, Jacobs has relied upon, and presumed accurate, information (or confirmation of the absence thereof) provided from published sources. These sources include AEMO's Draft 2024 ISP, AEMO's 2024 Gas Statement of Opportunities (GSOO), the National Greenhouse and Energy reporting (NGER) datasets, the National Greenhouse Gas Inventory (NGGI) datasets and Victorian Government announcements in relation to key policy programs in the electricity, gas and transport sectors. Except as otherwise stated in the report, Jacobs has not attempted to verify the accuracy or completeness of any such information.

This assessment was undertaken prior to the release of AEMO's 2024 ISP. Consequently, the analysis presented herein does not incorporate data from the 2024 ISP and is based on AEMO's 2024 Draft ISP. References to the ISP within this report, unless otherwise specified, should be assumed to refer to the Draft 2024 ISP.

The assessment supporting this report was undertaken between 6 March 2024 and 17 June 2024. The passage of time, manifestation of latent conditions or impacts of future events may require further examination of the project and subsequent data analysis, and re-evaluation of the data, findings, observations and conclusions expressed in this report. Jacobs has prepared this report in accordance with the usual care and thoroughness of the consulting profession, for the sole purpose described above and by reference to applicable standards, guidelines, procedures and practices at the date of issue of this report. For the reasons outlined above, however, no other warranty or guarantee, whether expressed or implied, is made as to the data, observations and findings expressed in this report, to the extent permitted by law.

This material has been prepared on behalf of, and for the use of Infrastructure Victoria, and is subject to, and issued in accordance with, the provisions of the contract between Jacobs and Infrastructure Victoria. Jacobs accepts no liability or responsibility whatsoever for, or in respect of, any use of, or reliance upon, this report by any third party.

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Acronyms and abbreviations

Abbreviation/Acronym	Definition
AEMC	Australian Energy Market Commission
AEMO	Australian Energy Market Operator
BEVs	Battery electric vehicles
c/kWh	Cost per kilowatt-hour
CCS	Carbon Capture Storage
CER	Clean Energy Regulator
CER	Consumer Energy Resources (interchangeable with DER)
CIS	Capacity Investment Scheme
CO_2-e	Carbon dioxide equivalent
DEECA	Department of Energy, Environment and Climate Action
DER	Distributed Energy Resources (interchangeable with CER)
DTP	Department of Transport and Planning
ESC VDO	Essential Services Commission Victorian Default Offer
FCEVs	Fuel cell electric vehicles
GPG	Gas-powered generation
GSOO	Gas Statement of Opportunities
GSP	Gross State Product
GW	Gigawatt
ISP	Integrated System Plan
IV	Infrastructure Victoria
J	Joules
Mt	Megatonne
Mtpa	Million tonnes per annum
MW	Megawatt
NEL	National Electricity Law
NEM	National Electricity Market
NSW	New South Wales
ODP	Optimal development path
PHEV	Plug-in hybrid electric vehicles
PJ	Petajoules
POE	Probability of Exceedance
PV	Photovoltaic
RETAs	Renewable Energy Target Agreements

Abbreviation/Acronym	Definition
REZ	Renewable Energy Zone
SA	South Australia
TWh	Terawatt-hours
VEU	Victorian Energy Upgrades
VIC	Victoria
VPP	Virtual Power Plant
VRE	Variable Renewable Energy
VRET	Victorian Renewable Energy Target
VTIF	Victorian Transmission Investment Framework

1. Introduction

The Victorian Government has committed to reducing Victoria's emissions by 75–80% by 2035 and achieving net-zero emissions by 2045. This includes renewable electricity targets of 65% by 2030, increasing to 95% by 2035 (DEECA, 2024b). Significant infrastructure projects need to be planned, designed and implemented in order to achieve these targets. Victoria, like many parts of the world, is facing risks to energy infrastructure projects, such as slow planning approvals, grid connection challenges, community opposition, rising construction costs, labour shortages and material price increases.

The Integrated System Plan (ISP) by the Australian Energy Market Operator (AEMO) (2024a) provides an integrated roadmap for the efficient development of the National Energy Market (NEM) over the next 20 years and beyond. Its primary objective is to optimise value to end consumers by designing the lowest cost, secure and reliable energy system capable of meeting emissions trajectories determined by policy makers. However, the energy transition is complex and involves multiple stakeholders. For certain sectors, the transition away from fossil fuels such as gas, petrol and diesel will increase the demand on the electricity grid as it transitions from coal-fired electricity to variable renewable energy sources. The timing of the electricity transition and the sequencing of increased load from other sectors could impact this transition. This could result in various impacts on energy reliability and security, cost and affordability, and associated social, economic and environmental impacts.

1.1 Project background

1.1.1 Project objectives

This project will help inform Infrastructure Victoria's update to the state's 30-year infrastructure strategy. The project involved undertaking a review of Victoria's planned energy transition, including its risks, current delivery, timing, sequencing and risk mitigation actions. This work focuses on mitigation actions the Victorian Government could take between 2025 and 2030 and between 2030 and 2035.

The key research questions for this project were:

- What are the key risks to achieving Victoria's planned energy transition up to 2030 and 2035, and what are their potential consequences?
- What actions, strategies and/or measures can the Victorian Government take to mitigate or minimise these risks to achieving the energy transition?

This report presents the method, analysis, results and discussion of the key risks and mitigation actions identified.

1.1.2 Project method

This project was delivered in four stages, namely: 1) project inception; 2) identification of key risks; 3) mitigation analysis; and 4) reporting. This report provides the approach, rationale and conclusions of the outputs and key findings.

For the purposes of this project, risks have been defined as "events that, if they occur, could have an impact on Victoria's decarbonisation objectives". A detailed method for the risk model development in Stage 2 of this project is provided in **Appendix B Risk Model Development**. In short, risks have been identified based on several key sources; a literature review, use of established models, and industry knowledge of the electricity, gas and transport sectors (including stakeholder engagement). The literature review informed the analysis of current and projected gaps in infrastructure against what is existing, planned, and needed. Key plans and roadmaps reviewed include the DEECA *2035 Emissions Reduction Target: Driving Real Climate Action* (2023), the Australian Energy Market

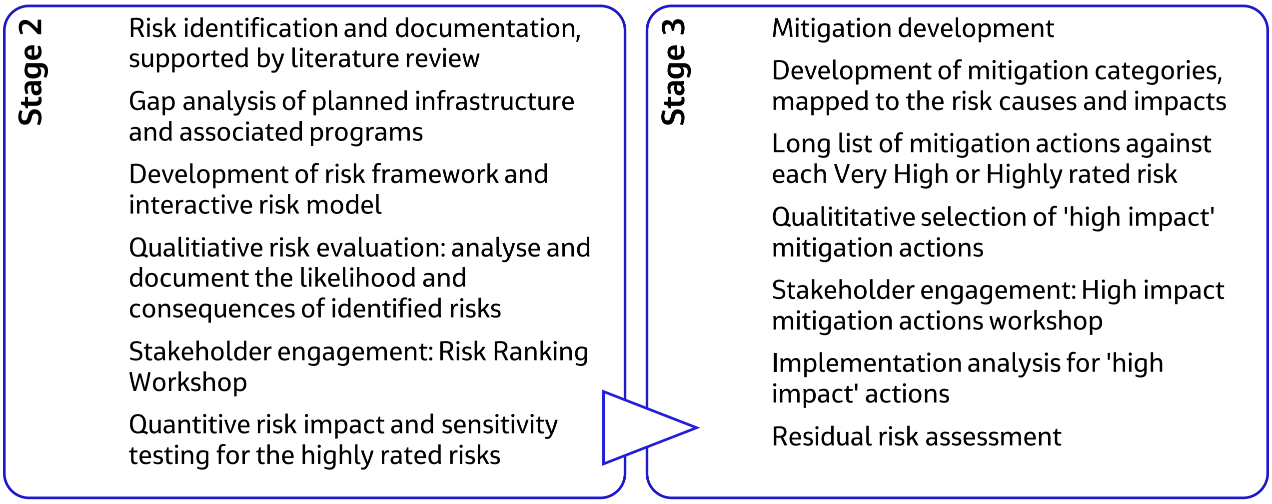

Figure 1-1 Methodology for Stage 2 and 3

Operator (AEMO) *Draft 2024 Integrated System Plan* (ISP) (2024a), and the AEMO *Gas Statement of Opportunities* (GSOO) (2024b).

An excel-based risk model was developed to provide a detailed and well-evidenced analysis of these risks. The model design enables risks to be assessed against key energy objectives, such as those outlined in the National Energy Objectives and the Victorian Climate Change Strategy. A qualitative risk assessment was undertaken to score the risks against a tailored risk matrix. Highly rated risks underwent additional assessment using modelling to provide further evidence to support the risk assessment.

Mitigation actions have been identified to reduce the likelihood of the risk occurring or the severity of the risk impact. The actions were qualitatively assessed to determine which were most material, or most likely to have the highest impact in affecting the overall risk profile against the very high and highly rated risks.

1.2 Emissions Targets

The Victorian Government has set interim targets along a path to net-zero emissions by 2045. The following targets are all reductions below 2005 emissions levels (DEECA, 2023b):

- 28–33% by 2025
- 45–50% by 2030
- 75–80% by 2035.

These targets are supported by the **Victorian Renewable Energy Targets** (DEECA, 2024b) of:

- 25% by 2020 (achieved)
- 40% by 2025
- 65% by 2030
- 95% by 2035.

They are also supported by Offshore Wind targets (DEECA, 2024a), legislated in March 2024, of:

- at least 2 gigawatts (GW) of offshore generation capacity by 2032 – enough to power 1.5 million homes
- 4 GW by 2035
- 9 GW by 2040.

Energy storage targets (DEECA, 2024b) have also been set, which include short, medium and deep duration energy storage systems. This allows energy to be moved around during the day and also to be supplied through longer duration imbalances. Targets include the following:

- At least 2.6 GW of energy storage capacity by 2030
- At least 6.3 GW by 2035 – enough to power around half of Victoria's current homes at their peak energy use.

1.3 Victoria's transition plan

This section outlines Victoria's planned approach to the energy transition. This is detailed through a summary of key policies, plans and roadmaps to support the energy transition in the electricity, transport and gas sectors. Various supporting government programs and investment schemes are also described in **Table 1-2.** For a full list of references, refer to **Section 6**.

Findings from the policy review have been used to identify gaps for Victoria's planned energy transition up to 2030 and 2035. Key findings from this review include the following:

- Electricity is the largest emitting sector in Victoria and lies at the heart of the transition to a low-emissions economy (see **Figure 1-2**).
- The electricity sector is already undergoing a transformation as renewable energy is built to replace historic reliance on thermal generation.
- Electricity is critical to decarbonise the transport and direct combustion sectors, which are the next two largest sources of emissions (excluding agriculture).
- Priority actions include the transition of vehicle fleets to electric propulsion and replacement of gas with electricity where feasible for domestic, commercial and industrial uses.

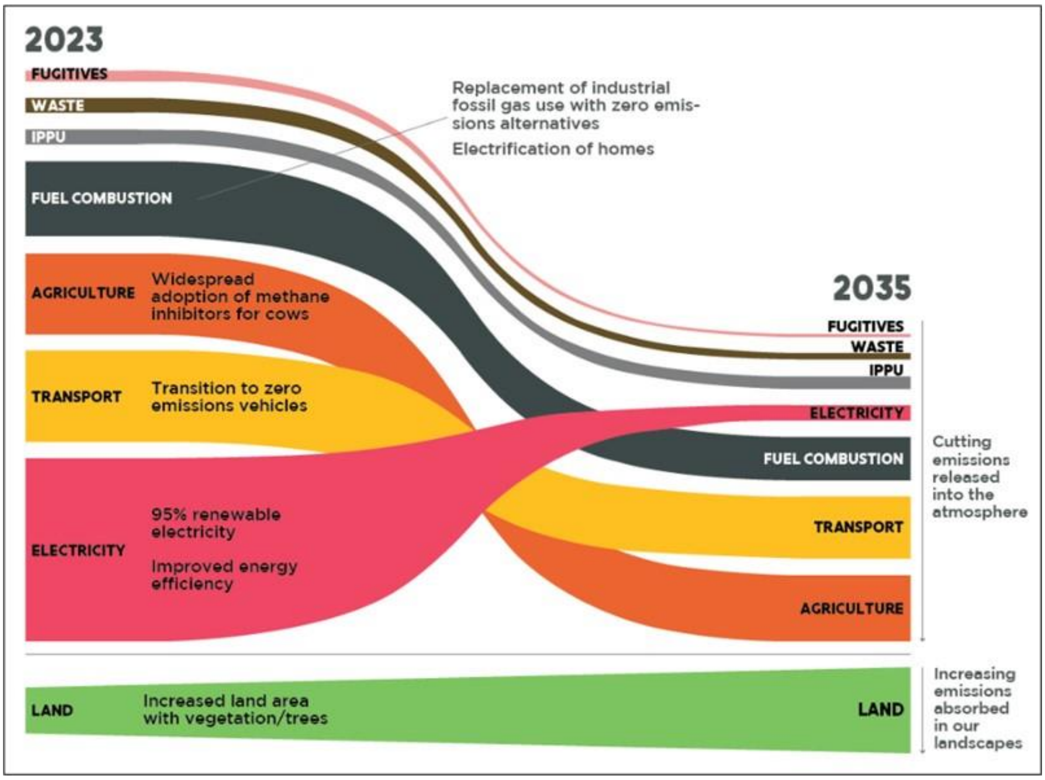

Figure 1-2 Illustrative pathway and key changes from today to Victoria's 2035 target.
Source: www.climatechange.vic.gov.au/climate-action-targets

1.3.1 Electricity sector

AEMO's Integrated System Plan (ISP) (2024a) is the principal long-term plan for the electricity sector to deliver the infrastructure necessary to achieve a net zero future. The Draft 2024 ISP outlines the changes that will be required to meet State Government emissions and renewable energy targets, which includes significantly increasing the capacity of grid-scale renewable energy and storage. Increased consumer adoption of renewable energy technologies will also be necessary to meet the emissions goals and renewable energy targets as set out by the Victorian Government.

To identify the optimal development path to a low-emissions future, AEMO's Draft 2024 ISP tests different development paths against three scenarios of the future:

- *Step Change*
- *Progressive Change*
- *Green Energy Exports*.

The *Step Change* scenario is consistent with Australia fulfilling its emissions reductions and a 1.5°C global warming scenario. The *Progressive Change* scenario reflects slower economic growth and energy investment. The *Green Energy Exports* scenario sees strong industrial decarbonisation and low-emission energy exports.

After extensive consultation, the *Step Change* scenario has been adopted as the most likely scenario (43%). The 'optimal development path' sets out the capacity of new generation, storage and transmission needed in the NEM through to 2050. It is tested against the *Step Change* scenario. Throughout this report, the analysis uses the optimal development path under the *Step Change* scenario in the ISP as the basis of the analysis.

Under the optimal development path *Step Change* scenario, the ISP outlines the anticipated growth and investment needed to meet government emissions reduction targets. This scenario sets growth assumptions in the following key areas as shown in the table below.

These assumptions cover the following key areas:

Table 1-1 Generation capacity (refer also **Figure 1-3**)

	FY25	FY30	FY35
Total capacity	23 GW	31 GW (+9 GW)	42 GW (+19 GW)
Renewables	14 GW	22 GW (+8 GW)	31 GW (+17 GW)
Energy Storage	3 GW	6 GW (+2 GW)	10 GW (+7 GW)
Brown coal capacity is set to retire entirely by the end of FY33 under the ISP step change scenario, removing 5 GW of capacity from the Victorian generation pool and the vast majority of Victoria's electricity sector emissions (AEMO, 2024a). Figures within the brackets represent the increase in generation capacity from 2025.			

Joule

The joule is the standard unit of energy in general scientific applications. One joule is the equivalent of one watt power radiated or dissipated for one second

Petajoule

One petajoule is 1 million billion joules, or 278 gigawatt hours

Kilowatts (KW) and KWh

- A thousand watts
- Typical consumers use 13 KWh per day on average (AEMC residential electricity price trends)

Megawatt (MW) and MWh

- A million watts
- A typical coal plant has a capacity of about 600 MW
- 600 MW in any hour would equate to about 200,000 homes assuming 3 Kw at peak.
- The Bald Hills Wind Farm comprises 52 turbines of 2.05 MW capacity each

Gigawatt (GW) and GWh

- A billion watts
- Large hydroelectric dam scan generate GW of power. The Snowy Mountains scheme has a total generating capacity of nearly 4.1 GW

Terawatt (TW) and TWh

- A trillion watts
- A terawatt-hour is one trillion watts of power for one hour (or 1,000 GWh).
- Total electricity generationin Australia in 2022 was around 273 TWh and renewable generation was 88 TWh (DCCEEW, 2024)

Transmission

- ISP projects under the optimal development path in the Step Change scenario in the ISP include the committed Western Renewables Link set to commence in 2027 and the two actionable projects of Marinus Link (stages one and two online between June 2030 and Dec 2032) and Victorian – New South Wales Interconnector West (VNI West) online between December 2028 and December 2029 (AEMO, 2024a).
- The ISP assumes the development of significant Renewable Energy Zone (REZ) transmission capacity to allow for investment in variable renewable energy in these areas, including in areas for offshore wind development. This sees 4.5 GW of new capacity developed in REZs by 2030 and 22 GW by 2050. The build of new capacity in REZs prior to FY30 occurs mostly in the South West Victoria and Gippsland REZs using existing capacity (AEMO, 2024a).
- Between 2030 and 2035, key REZ GW developments include Murray Valley, Gippsland, Gippsland Coast and Portland Coast. The coastal REZs in particular, support the achievement of offshore wind targets set by the Victorian Government (AEMO, 2024a).

Customer

- Rooftop PV is set to increase from 5.3 GW in FY25 to 8.3 GW (+3 GW) by FY30 and 11 GW (+2.7 GW) by FY35 (AEMO, 2024a).
- Embedded storage to increase from 400 MW in FY25 to 1.7 GW in FY30 and 3.8 GW in FY35 helping to support and manage the growth in rooftop PV in the same timeframe (AEMO, 2024a).
- Electrification of gas loads and growth in EVs in the ISP step change scenario are set to see increases in electricity load of 0.5 TWh by FY25, 5 TWh by FY30, 12 TWh by FY35 and 36 TWh by 2050. These are significant increases when compared to the existing load in Victoria (AEMO, 2024a). Total electricity load reported for Victoria in FY23 by the AER is 43.7 TWh (AER, 2024).
- Peak load is set to increase significantly in winter in Victoria from a 1 in 2-year (or expected) load of 7,787 MW in FY24 to 11,129 MW by FY35 and 13,433 MW by 2050, surpassing summer 1 in 2-year load by this time. More extreme 1 in 10 year peak loads, increase in summer from 10,178 MW in FY24 to 12,813 MW by FY35 and 14,088 MW by 2050 (AEMO, 2024a)[1].1 in 10 probability demands are used for

[1] 1 in 2 refers to 50% POE demand. Under AEMO industry terminology, this implies there is a 50% probability of the forecast being met or exceeded. 1 in 10 or 10% POE demand means 10% of actual demand values are expected above and 90% of actual demand values are expected below. See https://aemo.com.au/en/learn/industry-terminology

planning purposes by the electricity industry to plan for peak demand events that may not occur every year.

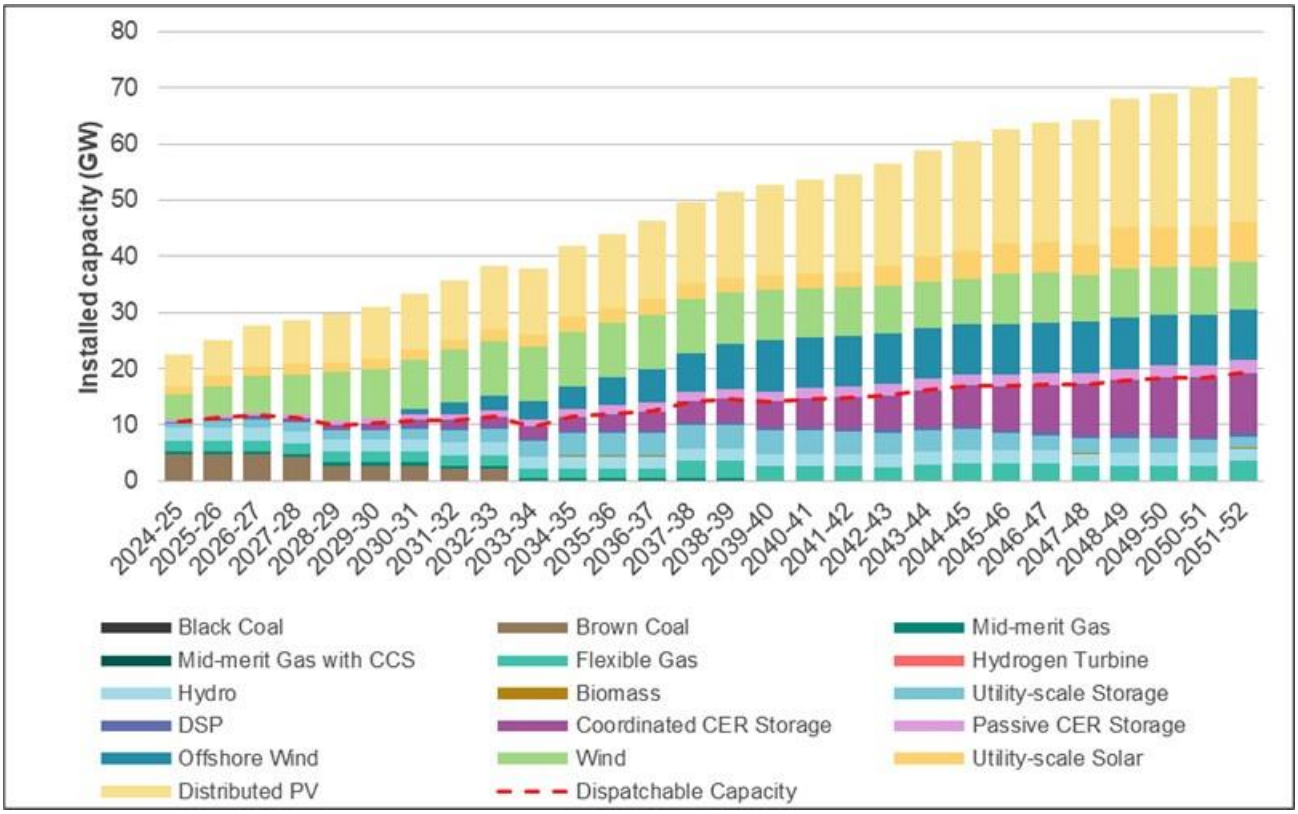

Figure 1-3. AEMO 2024 Draft ISP Generation Capacity Victoria – AEMO Draft ISP results workbook

1.3.2 Transport sector

Types of EVs (Electric Vehicles)
ZEV stands for Zero Emissions Vehicle. A **BEV** (Battery Electric Vehicle) is a type of ZEV.
A **PHEV** (Plug-in Hybrid Electric Vehicle) is not a ZEV and has both a battery and a normal petrol or diesel engine.

Current projections in the ISP see a large uptake in battery electric vehicles and plug-in hybrid electric vehicles by as early as 2030 (AEMO, 2024a).

AEMO (2024a) assumes there will be 45,000 electric vehicles and hybrid electric vehicles on Victorian roads by June 2024, with this figure increasing to 850,000 by FY30 and 2.2 million by FY35. By 2050, 4.9 million BEVs and PHEVs are expected on Victoria's roads. There were 5.2 million vehicles registered on Victoria's roads in 2023. Progress towards the June 2024 assumption is very positive, with DITRDCA (2023) reporting 79,700 BEV/FCEVs as of January 2023.

1.3.3 Gas sector

The gas sector plays two roles in Victoria's decarbonisation journey. Firstly, it supports the transition away from coal-fired generation by providing an alternative source of firming generation using existing infrastructure and generation assets. Secondly, as a source of emissions, the gas sector can contribute to emissions reductions by substituting gas with lower-emissions alternatives such as electricity and renewable fuels.

Under the *Step Change* scenario, the ISP sees a continuing role for gas-fired power in Victoria during the transition, using the existing stock of 2.4 GW of gas-fired generation capacity (AEMO, 2024a).

Additional flexible gas-fired generation capacity of 1 GW is added in Victoria in FY38 (AEMO, 2024a). Generation volumes from gas increase from 0.02 TWh in FY25 to 1.2 TWh by FY35 and 3 TWh by FY45 (AEMO, 2024a). The recently published Victorian Annual Gas Planning Report (VGPR) (2024e) notes potential variability in gas demand for generation in Victoria between 2 PJ and 20 PJ, driven by weather variations and the need for additional energy when coal generators are out of service (AEMO, 2024e).

In terms of alternative fuel development, no hydrogen turbines are included in the ISP *Step Change* scenario in Victoria (2024a). However, total domestic Victorian consumption of hydrogen for all uses grows from 0.006 Mt (0.85 PJ) in FY30 to 0.124 Mt (17.6 PJ) in FY35 and 0.217 Mt (31 PJ) in FY45 (AEMO, 2024a). No contribution is assumed from biomethane (AEMO, 2024a). The recently published GSOO report for 2024 shows that hydrogen and biomethane together could help to reduce domestic demand for fossil gas across east coast markets by 30 PJ by 2035, noting, however, that between the 2023 GSOO and the 2024 GSOO publication, no new renewable gas projects were committed (AEMO 2024b).

The GSOO report forecasts a peak in gas connections at 5 million connections (2.3 million connections in Victoria) in 2024 and shows total connections declining to under 3 million by FY35 (AEMO, 2024b). Under the step change scenario, AEMO sees a reduction in gas demand of 100 PJ across all east coast markets by 2035 (see figure 12 from GSOO below) (AEMO, 2024b).

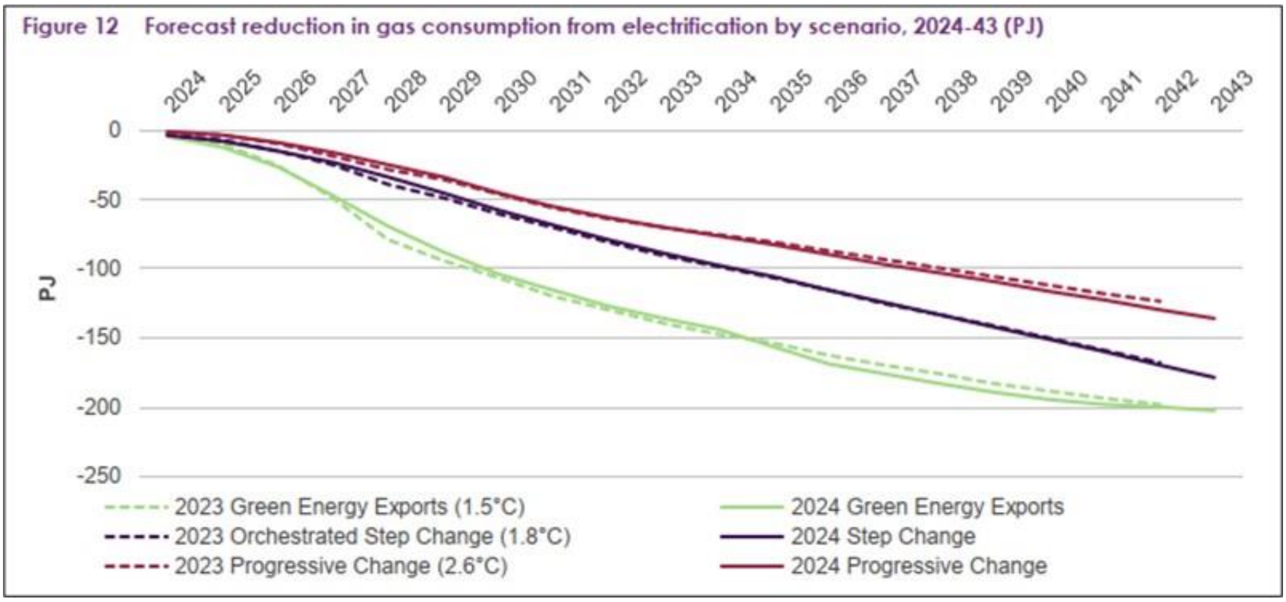

Figure 1-4. Forecast reduction in gas consumption for total east coast gas market from electrification from the Australian Energy Market Operator (AEMO) Gas Statement of Opportunities (AEMO, 2024b).

In Victoria, electrification in the latest GSOO sees 38 PJ of load reduction by 2030 and 68 PJ of load reduction by 2035 (AEMO, 2024b). Non-gas-powered generation (i.e. residential, commercial and industrial) gas load in Victoria is forecast at 176 PJ for 2024, with 118 PJ in residential and commercial, and 58 PJ in industrial load (AEMO, 2024b). Most electrification is forecast for residential and commercial usage. This level of electrification represents a reduction in residential and commercial gas consumption of greater than 50% by 2035 (AEMO, 2024b).

Electrification also plays a key role in managing gas supply issues forecast in Victoria and southern gas markets projected through AEMO's GSOO and Victorian gas planning report processes.

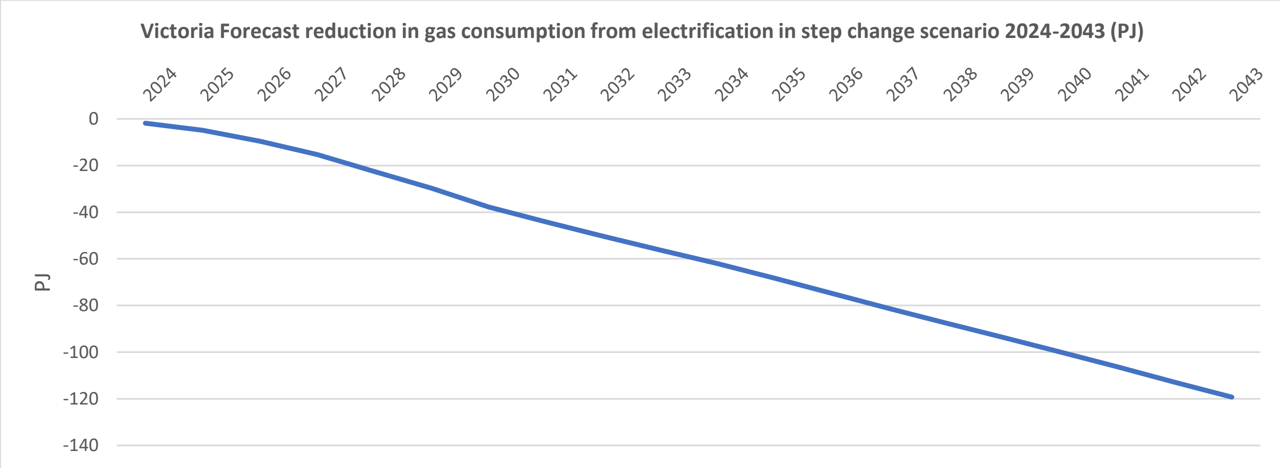

Figure 1-5. GSOO forecast of reduction in gas consumption from electrification in Victoria (AEMO, 2024b)

1.3.4 Planned investments and programs

Victorian and Australian Government programs and investment schemes cover all three of the major emissions sectors in Victoria covered in this report: electricity, direct combustion (including fossil gas) and transportation. They cover centralised infrastructure and planning and the transformation in the customers' use of energy. A summary of planned investments and programs is detailed below in **Table 1-2.**

Table 1-2. Summary of planned government investment and programs for electricity, gas and transport (as of 3/5/2024)

Area	Program	References
Renewables	VRET (65% 2030, 95% 2035). VRET renewable energy auction scheme – VRET2 Victorian Storage target (2.6 GW 2030, 6.3 GW 2035) Offshore wind target (>2 GW 2032, 4 GW 2035, 9 GW 2040) CIS 18 GW under RETAs, 14 GW under direct commonwealth bid rounds (of which 600 MW allocated to VIC and SA combined under dispatchable capacity tender and 1.4 GW allocated to Victoria for renewable energy under May 2024 tender)	DEECA (2022c) Victorian Renewable Energy Target Auction (VRET2) DEECA (2024b) Victorian renewable energy and storage targets DEECA (2024a) Offshore wind energy DCCEER (2022) Capacity Investment Scheme DCCEEW (2024) Reliable Renewables plan boosting energy supply in Victoria and Tasmania
Customer electricity transition	Small-scale Renewable Energy Scheme (SRES) Solar Homes Program Community Solar Banks Initiative Solar for Apartments Victorian Energy Upgrades (VEU) Solar Victoria's Residential Electrification Grants Program 7-star building efficiency standards Project EDGE 100 Neighbourhood Batteries Program	Clean Energy Regulator (2024). Small scale renewable energy scheme Solar Victoria (2020). Solar Homes and the Grid of the Future DCCEEW (2024a). Community solar banks DEECA (2024l). Solar for apartments program DEECA (2024c) Victorian energy upgrades for households Solar Victoria (2024a). Solar Victoria's Residential Electrification Grants Program

Area	Program	References
	Energy Efficiency in Social Housing Program (EESHP)	DEECA (2023i). 7-star energy efficiency building standards Australian Energy Market Operator. (2023d). Project EDGE final report, AEMO DEECA (2024f). Neighbourhood batteries helping to drive down bills DFFH (2024). Energy efficiency in social housing
Networks	VicGrid REZ development program Grid of the Future	DEECA (2023a). VicGrid: Coordinating the planning and development of Victoria's Renewable Energy Zones Solar Victoria. (2020). Solar Homes and the Grid of the Future
Microgrids	Community Microgrid and Sustainable Energy Program Microgrid demonstration initiative	DEECA (2024g) Microgrids
First Nations	First Nations Clean Energy Strategy	DCCEEW (2023). First Nations clean energy strategy: consultation paper.
Gas and renewables gases	Gas Substitution roadmap Renewable Hydrogen Industry Development Plan	DEECA (2023m). Victoria's Gas Substitution Roadmap. DEECA (2020), Victorian Renewable Hydrogen Industry Development Plan.
Transport	Zero Emissions Vehicle Roadmap Driving the nation fund	DEECA (2024i). Zero Emissions vehicles roadmap Department of Infrastructure, Transport, Regional Development, Communications and the Arts. (2024). New Vehicle Efficiency Standard DCCEEW (2024c). Driving the nation fund

2. Risk identification

A long list of risks to Victoria's energy transition was identified via industry knowledge, literature review and a gap analysis of existing, planned and needed infrastructure and associated programs. Modelling using the SEAM and PLEXOS models was also undertaken to support identification and quantification of these risks (refer **Section 3.2**).

2.1 Literature review

A wide range of publicly available policies, strategies and plans were reviewed to support identification and assessment of the risks, in addition to analysis literature from Infrastructure Victoria and groups such as the Grattan Institute, industry bodies and news articles. Refer to **Section 6** of this report for a list of the references used in supporting the risk identification. Much of the literature review was also used to support the gap analysis in **Section 2.2** and to provide evidence for subsequent risk ratings.

A key document was the AEMO 2024 Draft ISP. Note that the Final ISP was released on 26 June 2024. It is assumed that the revisions in the Final ISP do not change the overall conclusions of this project.

2.2 Progress analysis (gap analysis)

Analysing infrastructure against what is existing, planned, and needed identifies where there may be risks to achieving decarbonisation goals. Using the transition plan outlined in **Section 1.3,** the progress analysis particularly focuses on electricity infrastructure needs (interconnectors, transmission, generation, storage, distribution, and consumer energy resources) up to 2030 and 2035. Note that there may be changes assumed during the transition that require additional support or programs to address the degree of change required in the timeframe.

Table 2-1 below outlines the milestones that are assumed to be achieved in the course of the ISP, and analysis in the table is explained as one of two options:

- 'Programs match objectives' means there are programs in place that target the change assumed in the ISP.
- 'More action needed' means there may be programs in place, but they may not provide a clear pathway at this stage towards the achievement of a milestone.

Table 2-1 Progress analysis, including the milestones assumed to be achieved to meet Draft 2024 ISP and 2024 GSOO projections, and government programs assumed to help achieve those milestones

Milestone	Unit	Draft 2024 ISP step change / 2024 GSOO			Analysis	Discussion, refer Section
		2025	2030	2035		
Coal retirements	GW Capacity Operation	4.8	2.8	0	More action needed	2.2.1
VRE capacity (excl rooftop PV)	GW Capacity	5.9	10.6	16.4	Programs match objectives	2.2.2
Rooftop PV	GW Capacity	5.3	8.3	11	Programs match objectives	2.2.3
Clean dispatchable capacity (excl embedded storage)	GW Capacity	2.9	3.9	6.4	Programs match objectives	2.2.4

Milestone	Unit	Draft 2024 ISP step change / 2024 GSOO			Analysis	Discussion, refer Section
		2025	2030	2035		
Embedded storage	GW Capacity	0.4	1.7	3.8	More action needed	2.2.5
Transmission developments	Development		VNI West Dec 2028	Marinus Link Stage 1 June 2030 Stage 2 June 2032 REZ1-8 Major capacity expansions	Programs match objectives	2.2.6
Electrification	PJ of load offset	4.8	37.8	68.3	More action needed	2.2.7
Renewable gas blending	PJ of hydrogen blended into Tariff V and D	0.03	1.8	9.6	More action needed	2.2.8
Energy efficiency (residential + business)	GWh	903	3,498	6,491	More action needed	2.2.9
Electric vehicles	Number of Vehicles	77,138	846,086	2,180,055	More action needed	2.2.10

A discussion of the rationale for the assessment under each of the main categories follows. This is a point in time assessment, noting that policies may evolve and trends for the take-up of decarbonising technologies may change over time.

2.2.1 Coal retirements

The Structured Transition Agreement in place between AGL and the Victorian Government (Victorian State Government, 2023b), secures closure of Loy Yang A by the 30 June 2035. In addition, Energy Australia has also announced the closure of Yallourn in mid-2028 (EnergyAustralia, 2021). These announcements provide some certainty around the closure of brown coal generation in Victoria and help to support investments in replacement firming technology. However, uncertainty around the closure of Loy Yang B remains, with its closure date listed as 2047 on the AEMO Generation information page.

Table 2-2 ISP assumptions for coal retirement against announced retirement dates

Station	ISP currently assumes the retirement of Victoria's brown coal fleet on the following dates	Current announced retirement dates
Loy Yang A	FY 2033	FY 2036 (formal agreement to close in 2035) (Victoria State Government, 2023b)

Loy Yang B	Unit 1 FY 2027, Unit 2 FY 2031	FY 2047 (AEMO generation information page, closure date)
Yallourn	FY 2028	FY 2028 (Energy Australia announced closure date) (Energy Australia, 2021)

2.2.2 Variable renewable energy (VRE) capacity

To reach renewable energy goals of 65% by 2030 and 95% by 2035, the ISP sees 10.6 GW of variable renewable capacity installed by 2030 and 16.4 GW by 2035 (excluding rooftop PV).

There are three key investment policies in place to help meet this objective. The Victorian Renewable Energy Target Auction (VRET2) will see 6 successful projects delivering 623 MW of new renewable generation capacity. The Commonwealth Government's Capacity Investment Scheme (CIS) is set to back 23 GW of variable renewable energy resources across the NEM prior to 2030 and would, assuming Victoria were to receive a demand-weighted share of capacity, see more than 4 GW of new capacity installed in Victoria (DCCEEW, 2024d).[2] The first auction of the CIS, which will support 6GW of new VRE capacity has received more than 40GW of project registrations(Parkinson, 2024).

The Victorian Government's offshore wind development program has set legislated targets to deliver:

- At least 2 GW of offshore generation capacity by 2032
- 4 GW by 2035
- 9 GW by 2040.

These programs and targets will help to meet the 10 GW capacity build assumed in the ISP by 2030, however, not all capacity to reach 2035 goals is announced. It is also difficult to predict whether the build-out will occur according to schedule, given the challenges associated with offshore wind development and that Australia and Victoria do not yet have a track record of offshore wind development.

2.2.3 Rooftop PV

Under AEMO's ISP, rooftop PV capacity in Victoria grows from 4.7 GW in 2023, to 8.3 GW in 2030 and 11 GW by 2035. This implies an additional rooftop PV capacity of 573 MW per annum for the next 11 years.

The achievement of this is supported by recent trends in the growth of installed rooftop PV capacity in Victoria in excess of this annual figure (Clean Energy Regulator, 2023). According to data from the Clean Energy Regulator's quarterly carbon market report, Victoria installed 612 MW of small-scale rooftop solar PV in calendar year 2023, 541 MW in 2022 and 675 MW in 2021.

The ongoing uptake of rooftop PV by Victorian households has been supported by the Small-scale Renewable Energy Scheme and the Solar Homes Victoria Program.

2.2.4 Clean dispatchable capacity[3]

The ISP sees 3.9 GW of clean dispatchable capacity installed by 2030 and 6.4 GW by 2035, versus the 3 GW installed today (2.2 GW hydro plus utility scale storage systems).

The legislated Victorian Energy Storage Target is the key program by which the projections under the ISP are likely to be progressed in the timeframe. Short, medium and deep duration energy storage systems are

[2] Victoria has negotiated a share of the first 6 GW of wind and solar contracts that will be auctioned in the first 2024 tender of the Capacity Investment Scheme. Victoria will receive an allocation of 1.4 GW from this round.

[3] Clean dispatchable capacity includes hydro and battery storage in Victoria

included under this target which aims to install 2.6 GW by 2030 and 6.3 GW by 2035. The ISP projections are also addressed by the VRET2 auction, which sees up to 365 MW and 600 MWh of new battery energy storage being installed.

Recent project commitments also demonstrate progress in the planning and building of dispatchable capacity in Victoria. For example, the 600 MW/1600 MWh Melbourne Renewable Energy Hub (Stage 1) reached financial close in February 2024 (Equis, 2024). The Commonwealth's CIS scheme has also allocated 600 MW of 4-hour equivalent (or 2,400 MWh) of dispatchable capacity to Victoria and South Australia in a combined pilot tender. The tender will allocate a minimum of 800 MWh to Victoria, 800 MWh to South Australia and an additional 800 MWh to either South Australia or Victoria based on the assessed merit of projects. (DCCEEW, 2024f).

2.2.5 Embedded storage

The ISP step change scenario sees embedded storage capacity increasing from 263 MW in 2024 to 3.8 GW by the end of the 2035 financial year, an increase of over 3.5 GW. Assuming 5 kW of capacity per system, this would require 700,000 homes in Victoria to install batteries. There is uncertainty on the pathway to increase customer uptake of embedded storage demonstrated by the low level of penetration to date and the high outlook for embedded storage in the ISP by FY35.

Currently, the Clean Energy Regulator's quarterly carbon markets report shows that only 8% of the Victorian households that installed a new solar PV system in the second half of 2023 did so with a battery storage system. Based on the proportion of households adding storage when making a new installation, an addition or extension to an existing installation or a replacement, this was just over 5,000 battery storage systems in Victoria in 2023 (Clean Energy Regulator, 2023). The investment decision for embedded storage is not yet clearly compelling for consumers, although this may change with further reductions in costs and changes in the tariff incentives for rooftop batteries (AEMC, 2023).

The 100 Neighbourhood Batteries Program Implemented by DEECA aims to provide neighbourhood scale batteries that range from 50 kWh to 10 MWh, storing excess solar-generated electricity during the day and releasing it during peak evening demand. Six projects will share in more than $10 million for 25 neighbourhood batteries across 20 towns, delivering more than 4.2 megawatt hours of new storage capacity under the first round of the 100 Neighbourhood Batteries Program.

The Solar Home program entitles eligible households and rental property owners to claim a rebate of up to $2,225 for the cost of purchasing and installing a solar PV system, with the remaining cost to be paid through an interest free loan. Over 110,000 Victorians have benefited from the program since its launch in August 2018, demonstrating a growing trend towards localised and distributed energy generation across the state. As part of this program, the Solar Victoria interest free battery loan was created to reduce the upfront cost of installing a battery, with repayments made over a four-year period. Loans of up to $8,800 are available in 2023-24 (Solar Victoria, 2024b). However, there are a number of limiting criteria in this battery loan program: it is only open to owner occupiers, the combined household income must be under $210,000 per year, and the property must be worth less than $3 million.

There have been recent announcements in relation to network operators introducing solar export tariffs for consumers, and incentives for export to the grid outside solar peak hours. This follows a rule change from the AEMC in 2021 on CER/DER (consumer energy resources/distributed energy resources) access and pricing that allowed for the introduction of solar export tariffs. Solar export tariffs that disincentivise export during peak solar hours and incentivise export at other times, provide an additional incentive for embedded storage installation.

A required Installation regarding 3.5 GW of embedded storage capacity, with roughly 700,000 systems needed by 2035, or over 60,000 per annum (assuming 5 kW of capacity per system), may be hard to achieve without further change in the financial incentives from the market or additional support from policymakers.

In addition, while there are programs related to the electricity distribution network, such as Grid of the Future (Solar Victoria 2020), there does not appear to be a holistic vision looking at AEMO's forecasts for changes in maximum demand in summer and winter, changes in rooftop PV, expected and potential battery take-up rates, and therefore, the need to either augment different distribution networks to a different extent at different times, or find ways to better manage the greater loads on the network through distributed storage or greater management of DER resources. Some networks may have more spare capacity in different regions than others, depending on the history of network development and demand growth in different regions.

2.2.6 Transmission

Transmission developments in Victoria to support the build of new variable renewable energy (VRE) and clean dispatchable capacity, as well as the import of capacity from adjoining regions, are supported through the ISP and RIT-T framework, and in the case of renewable energy zones, through the establishment of VicGrid. VicGrid is responsible for coordinating the planning and development of Renewable Energy Zones in Victoria and investing $480 million in projects to strengthen and modernise Victoria's energy grid (DEECA, 2023a). VicGrid was established by the Victorian Government in 2021 as a division within the Department of Energy, Environment and Climate Action.

There are three major transmission projects either committed or actionable for Victoria in the ISP which are the Western Renewables Link, Project Marinus and VNI West. These projects have all been subject to delays in their planning phases (EY 2024, Powering progress). Further delays present a continuing risk to the transition of the NEM and the achievement of emissions reductions objectives.

2.2.7 Electrification

Electrification numbers under the ISP assume 37.8 PJ of gas load offset by electrification by 2030 and 68.3 PJ by 2035. The majority of this is in the residential and commercial sector. In 2024, AEMO has gas load in the residential and commercial sector in Victoria at 118 PJ. This degree of electrification would see a halving of gas usage in Victorian homes and commercial applications over 11 years.

The ambition for the electrification of gas loads has also been set out in the gas substitution roadmap and policies are currently in place. However, the pace of transformation required in the reduction in the number of gas connections and the number of gas appliances in Victorian households is high and there is no observed trend at present that suggests electrification targets will be met.

In July 2021, Energy Networks Australia (2021) reported 2.1 million Victorian homes, i.e., 76% of households, connected to gas, more than any other state or territory. They reported Victoria as having 5.2 million residential gas appliances, and gas appliances are generally seen to have a longer lifespan than electric appliances.

With this scale of gas connection and gas use embedded in Victorian consumer lives, the programs to shift these usage patterns need to not only restrict new gas connections but help switch a significant number of homes to all electric every year. It is not yet clear that the scale of the task is matched by programs to encourage the required degree of take up by existing households connected to gas, on an annual basis. On 28 July 2023, the Victorian Government announced that from 1 January 2024 planning permits for new homes and residential subdivisions, including public and social housing, will be prohibited from connecting to the gas network (Victoria State Government, 2023c). This is for new connections only. Additionally, the National Construction Code (NCC) 2022 has introduced several new requirements that encourage energy efficiency, which may indirectly promote the use of electric appliances, including thermal performance requirements and hole-of-home, annual energy use budget (NCC, 2022).

The Victorian Residential Electrification Grants program managed through Solar Victoria allocates funding to participating organisations to enable bulk installation in a minimum of 50 homes as part of a single scheme, project, or development, for the benefit of homeowners. It is not stated how much gas load is assumed to be reduced as a result of this program or what the overall target in homes converted is (Solar Victoria, 2024a).

The Victorian Energy Upgrades program has expanded to offer incentives of up to $3,600 to install a wider range of efficient electrical appliances such as heat pumps and reverse cycle air conditioners, while previous incentives for gas appliances have been phased out (DEECA, 2023m).

As part of the Victorian Government's update to the Victorian gas substitution roadmap, the government is also looking to expand the Victorian Energy Upgrades program to include incentives for upgrades to efficient electric cooktops, enabling all Victorians to fully electrify their homes through Victorian Energy Upgrades. As part of this update the Victorian Government is also undertaking a Regulatory Impact Statement to consider the costs and benefits of requiring existing gas appliances in homes and commercial buildings to be replaced with electric appliances when the current appliance reaches end of life. (Victorian Government, 2023m Gas Substitution roadmap). The SEC is also exploring options for a trusted one stop shop to assist Victorians to navigate the home electrification process, with pilot household solutions starting from 2024 (Victoria State Government, 2023a). Fees for disconnecting from the gas network have now been capped at $220, making it more affordable to go all electric.

However, the task is considerable. Grattan reported in a June 2023 report *Getting off Gas* (Grattan Institute, 2023) that roughly two thirds of gas appliances at end of life in Victoria need to be replaced with electric appliances every day in order for net zero targets to be met, however notes that while electric appliances offer cheaper operational costs, efficient electric appliances cost more to buy than gas appliances, by $1,850 more in the case of heating systems and $1,550 more in the case of hot water systems. In addition, Grattan also put forward that in Victoria the majority (greater than 50%) of gas users face barriers to electrifying including renting, low income, and insufficient savings to make the required investments. Some of these issues are currently under consideration, for example, the Victorian government is now consulting on minimum rental standards that include electrification of space heating and water heating appliances at end of life. (Victorian Government, 2024, minimum rental standards for rental properties and rooming houses). Such barriers, combined with the high cost of new appliances and the long life of existing gas appliances[4] mean programs and policies in relation to electrification may need to be expanded in order for electrification goals in the ISP to be met by 2035. It should also be noted that in the most recent federal budget delivered on 14 May 2024, there were no new measures introduced at a Commonwealth level to increase rates of household electrification.

2.2.8 Renewable gas blending

The 2024 GSOO sees over 1.8 PJ in 2030 and 9.6 PJ of renewable hydrogen blended in gas networks in Victoria by 2035. The ambition for the transition in carbon content of the gas molecule itself (to renewable gases such as biomethane and hydrogen) has been set out in the gas substitution roadmap, but policies remain to be developed and implemented.

The Victorian Government is focusing on scaling up biomethane and renewable hydrogen production across the state, to reliably power Victoria's manufacturing and industrial sectors. A policy directions paper will be released in 2024 reflecting stakeholder feedback to the Renewable Gas Consultation paper released in September 2023. This consultation paper discusses renewable gas targets and other policies intended to incentivise the production of renewable gases in Victoria, but as yet, no mandated target or requirement is in place (DEECA, 2023m).

Currently the economics of hydrogen blending in gas distribution networks is still challenging and so will rely on policy incentives or mandated targets to reach greater scale, and the scale implied by the volumes noted in the ISP. Currently the policies are not yet in place to provide these incentives.

[4] This is borne out by modelling from Jacobs SEAM model, assuming an asset life of 12-15 years for gas appliances.

2.2.9 Energy efficiency

The ISP assumes significant reductions in electricity consumption through energy efficiency. In Victoria, the residential load reduction assumes 2,183 GWh by 2030 and 3,969 GWh by 2035. For business loads, this is 1,315 GWh by 2030 and 2,522 GWh by 2035. This reaches a total of 6,491 GWh by 2035, or 6.5 TWh. This is a significant estimation as compared to Victoria's current load of 44 TWh (AER, 2024) and has a bearing both on the overall energy needed and peak energy requirements. If energy efficiency savings are not delivered, this will have a negative effect on the networks ability to operate as demand grows, a bearing on the amount of generation needed in the system and the amount of firming generation capacity at particular times of the day.

In the GSOO, energy efficiency savings are also assumed to be delivered, reducing gas loads for residential consumers. The 2024 GSOO assumes residential consumers can save 3.9 PJ by 2030 and 6.3 PJ by 2035, while larger loads save very little.

The key program that seeks to address energy efficiency is the Victorian Energy Upgrades program. This has supported 2 million Victorian households since 2009. Products include lighting, space heating and cooling, water heating and draft sealing (DEECA, 2024c). Additionally, Victoria's Energy Efficiency in Social Housing Program (EESHP) is a significant initiative aimed at improving the energy efficiency of social housing properties. The program is investing $158 million to support a range of cost-effective energy efficiency upgrades for 35,000 public, community and Aboriginal housing properties (DFFH, 2024). It is not clear, however, the extent to which equipment upgrades under these programs are likely to deliver the extent of energy efficiency savings assumed by 2035 in the ISP, and hence the extent of any shortfall in programs required to achieve the objectives in the ISP for energy efficiency by this date.

2.2.10 Electric Vehicles

The ISP sees growth in battery electric vehicles (BEV) and plug-in hybrid electric vehicles (PHEV) in Victoria from 45,000 as at the end of FY 2024, growing to around 846,086 in 2030 and over 2.2 million by the end of FY 2035. The Zero Emissions Vehicle Roadmap (DEECA, 2024i) sets out clear targets in relation to the numbers of EVs the government would like to see sold. The Victorian Government has a stated aim for half of all light vehicle sales in Victoria to be zero emissions vehicles (ZEVs) by 2030.

The key challenge for Victoria is the overall growth in the car fleet and the impact this has on emissions even if there are 2.2 million BEVs and PHEVs on the road in 2035. Victoria has a total of 5 million vehicles on the road currently (just under half are small and medium sized passenger vehicles), and based on projections in growth in the overall population (Department of Transport and Planning, 2023), is set to reach 6.4 million vehicles by 2035 (as shown in **Figure 2-1** below). The consequence of this is that projected emissions from road transportation in Victoria do not fall significantly by 2035. Instead, the government's target of 50% of light vehicle sales to be EVs by 2030, would likely need to increase, and supporting policies to be extended and upgraded.

There is, however, uncertainty regarding the types of incentives, support, infrastructure and pathway that will be needed to achieve EV uptake targets. For example, in 2023, the Victorian Government's $3000 subsidy for EV purchases was axed, citing factors including a lower than expected take-up rate. The scheme launched in May 2021 and had targeted 20,000 sales but was closed in 2023 with only 10,000 vehicles purchased under the scheme (Durkin, 2023) (Zachariah, 2023). Victoria has not introduced a similar subsidy-based scheme since the EV subsidy was removed.

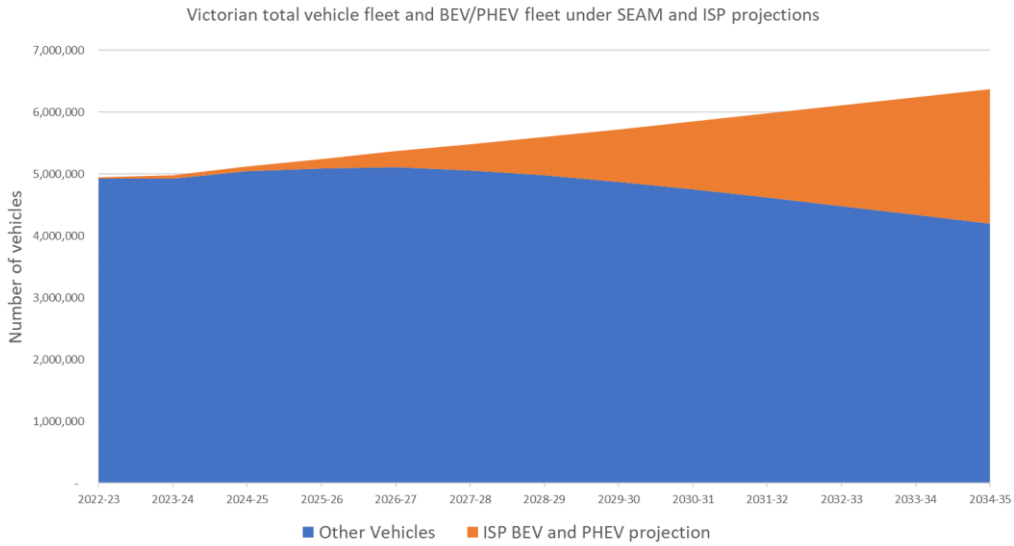

Figure 2-1 Victorian BEV, PHEV and total vehicles projected under ISP and SEAM projections

The Victorian ZEV plans also include $20 million for a public transport bus trial, with a target for new public transport bus purchases to be ZEVs from 2025, to replace 400 vehicles in the Victorian Government Fleet with ZEVs and $5 million to establish a Commercial Sector Zero Emissions Vehicle Innovation Fund to encourage ZEV technology. The Acceleration of Zero Emissions Vehicle Adoptions Programs also included a suite of programs including funding for EV charging for businesses and council, alongside grants to support innovative EV charging technologies.

The fund aims to support the adoption of ZEVs in commercial settings and will consider proposals such as direct purchase incentives for ZEVs, trials of ZEV technology with specific commercial applications, training programs to facilitate the industry's transition to ZEVs, and infrastructure support for vehicle charging within fleet depots. Additionally, it will assist in developing business cases for ZEV adoption. An investment of $46 million for a public ZEV subsidy program has been made for 20,000 ZEVs (DELWP, 2021).

At a national level, growing EV sales and new vehicles efficiency standards introduced by the Australian Government will drive greater momentum behind zero emissions vehicles. However, the scale of purchases required in the ISP is significant (DITRDCA, 2024).

3. Risk assessment

3.1 Risk rating

Risks have been defined for this project as "events that, if they occur, could have an impact on Victoria's decarbonisation objectives". Risks were assessed using a risk model developed and tailored specifically for this project, as described in **Appendix B Risk Model Development.** The impacts of risks have been categorised and scored against four areas of critical consequence for Victoria and Victorian consumers:

- Emissions
- Reliability, security and safety (RSS)
- Affordability
- Social equity

The risks identified were stress tested through a stakeholder workshop (refer to **Appendix C Stakeholder Engagement**) which resulted in some refinements. These risks were also analysed through modelling (refer **Section 3.2**) to quantify the risks where possible and provide outputs to support the risk rating.

Refer to **Appendix D Risk Register** for a more detailed excerpt of the risk register, with the risks defined in terms of "Cause", "Risk" and "Impact/Consequence" along with key supporting evidence to explain the ratings below. The following tables provide a summary of the risks identified and their risk rating. The tables indicate which of the four impact categories received the highest score.

Table 3-1. Very high rated risks

ID	Risk event	Impact/Consequence	Likelihood
VH1	Thermal power plants are run longer than expected (as per ISP)	Severe (emissions)	Likely
VH2	Offshore wind targets not met	Severe (emissions)	Likely
VH3	More frequent extreme climate weather events increase frequency and unpredictability of peak demand events	Severe (RSS)	Likely
VH4	Peak and annual gas supply shortfalls	Severe (affordability)	Likely
VH5	Existing gas customers don't electrify to the anticipated level per the ISP	Severe (emissions)	Likely
VH6	Lack of renewable gas developments	Severe (emissions)	Likely
VH7	Consumers uptake of battery electric vehicles (BEV) and plug in hybrid electric vehicles (PHEV) not high enough to achieve emissions objectives	Severe (emissions)	Likely
VH8	Major transmission project delays (Marinus Link, VNI West, V1-V8 REZs, Western VIC, Eastern VIC)	Severe (emissions)	Likely

Table 3-2. High rated risks

ID	Risk event	Impact/ Consequence	Likelihood
H1	Inadequate management of additional loads and flows on distribution networks	Major (all)	Likely
H2	Curtailment of variable renewable energy resources due to low minimum demand levels	Major (all)	Likely

ID	Risk event	Impact/ Consequence	Likelihood
H3	Households do not improve energy efficiency of their homes as much as projected	Major (all)	Likely
H4	Lack of customer take up of embedded and aggregated storage	Major (all)	Likely
H5	Increase in coal fired power outages	Severe (RSS)	Possible
H6	Extension of fire season reduces generation and transmission reliability, extreme weather impacts transmission reliability	Severe (RSS)	Possible
H7	Inadequate long duration storage in time for coal exit	Major (emissions, affordability, RSS)	Likely
H8	Spiralling gas network costs for remaining gas consumers	Major (affordability, social equity)	Likely
H9	EV charging profile is peakier than anticipated in the ISP	Severe (RSS)	Possible
H10	Development and funding risk for onshore VRE and clean dispatchable resources	Major (emissions, RSS)	Likely

Table 3-3. Medium rated risks

ID	Risk event	Impact/ Consequence	Likelihood
M1	Primary industries liquid fuel emissions not reduced	Major (emissions)	Possible
M2	Construction industry liquid fuel emissions not reduced	Major (emissions)	Possible
M3	Rooftop PV capacity added lower than projected in ISP	Major (all)	Possible
M4	Demand side participation not as great as projected in ISP	Major (emissions, affordability, RSS)	Possible
M5	Reduced hydro availability due to flow reduction due to climate change	Major (affordability, social equity, RSS)	Possible
M6	Increasing cost slows development of renewables	Major (emissions, affordability, social equity)	Possible
M7	Generator connection cost increases	Major (emissions, affordability, social equity)	Possible
M8	Increasing project development lead times	Major (emissions)	Possible
M9	High fuel price/affordability for consumers	Major (affordability, RSS)	Possible

ID	Risk event	Impact/ Consequence	Likelihood
M10	Shallow, medium and deep storage projects delayed	Major (emissions, RSS)	Possible
M11	Carbon Capture Storage (CCS) technology failure in delivering abatement at commercial cost	Major (emissions)	Possible
M12	Skilled workforce not available for Renewable Energy project development and operation	Major (emissions)	Possible
M13	First Nations energy strategy not implemented to degree anticipated	Major (emissions, social equity)	Possible
M14	Investor uncertainty due to market price signals	Major (emissions)	Possible
M15	Low incentives for landlords to transition properties away from fossil gas	Major (emissions, affordability)	Possible
M16	Electrification in business and industry slow	Major (emissions)	Possible
M17	Gas workforce is displaced and there are job losses in the sector	Major (social equity)	Possible
M18	Pattern of gas usage gets peakier, increasing costs	Major (affordability, RSS)	Possible
M19	Changes to key gas policy settings impact cost and availability of gas	Major (RSS)	Possible
M20	Technical limitations on hydrogen blending in gas networks	Major (emissions, RSS)	Possible
M21	Civil aviation emissions not reduced	Major (emissions)	Possible

Table 3-4. Low and very low rated risks

ID	Risk event	Impact/ Consequence	Likelihood
L1	Economic viability and scale of green hydrogen supply as gas-powered generation fuel and natural gas replacement	Major (emissions, RSS)	Unlikely
L2	Electricity demand for hydrogen electrolysis higher or lower than expected	Major (all)	Unlikely
L3	Risk or opportunity posed by introduction of carbon price	Major (emissions, affordability, social equity)	Unlikely
L4	Community microgrids do not transition to clean energy supply	Major (social equity)	Unlikely
L5	Safety incidents with new technology such as hydrogen and batteries slows uptake	Major (RSS)	Unlikely
L6	Railway emissions not reduced	Minor (emissions)	Possible
L7	Maritime transport emissions not reduced	Minor (emissions)	Possible
VL1	EV Vehicle to Grid (V2G) penetration not as high as projected	Minor (all)	Unlikely

3.2 Energy Modelling

In order to determine the quantitative impact of particular risks to Victoria's transition pathway, to support the risk identification and rating, modelling has been undertaken in the Sectoral Emissions and Abatement Model) and PLEXOS to determine the emissions, price and reliability pathway for Victoria. The modelling assumes Victoria achieves all the numbers detailed in the 2024 Draft ISP and the GSOO.

The SEAM model was used by Jacobs for DEECA to undertake projections of Victoria's emissions trajectory, under business-as-usual conditions and under alternative scenarios, with variations around technology costs, policy prescriptions, and uptake rates. This model was used to help DEECA develop the net zero targets for Victoria. The model assists with the current and ongoing projections of emissions on a sectoral basis. It provides insights on how emissions are tracking in comparison to the prescribed reduction targets under a range of economic, technological, and sociodemographic trends, and enables the modelling of alternative policy prescriptions.

PLEXOS is a software platform used to model long-term, medium term and short-term planning horizons in the electricity market. It can be used to simulate the operation of the electricity market, modelling the bidding behaviour of generators, the cost of generation, the dispatch of generation and the price of wholesale electricity over different time frames and in different regions of the market. Key scenarios on the future of the NEM can be tested to inform emissions impacts and impacts in relation to price, affordability and security and reliability.

Refer also to **Appendix A Additional modelling information** for more detail on the models, and modelling assumptions, used in this assessment.

3.2.1 SEAM

3.2.1.1 Base case

The SEAM base case is a representation of Victoria's emissions pathway assuming the goals and objectives under the ISP and GSOO are met. The ISP considers Victoria's emissions targets and policies to meet these targets.

Victoria has set targets to reach net zero by 2045 and set targets (reductions below 2005 levels (DEECA, 2023b)), on the path to net zero:

- 28-33% by 2025
- 45-50% by 2030
- 75-80% by 2035.

The modelling input assumptions for the base case are based on the Draft 2024 AEMO ISP Step Change scenario (AEMO, 2024a), the assumptions in the GSOO (AEMO, 2024b) and includes assumptions on the retirement of all brown coal generators by 2035, relatively low output for gas-powered generation over the period, significant electrification of the gas sector, large growth in the number of EVs on the road and some blending of hydrogen in gas networks. Other base line information in relation to other key emissions areas of the Victorian economy is outlined in **Appendix A Additional modelling information.**

The forecast emissions trajectory, taken from SEAM modelling and shown in **Table 3-5**, can be seen to meet Victoria's emissions objectives for 2030 and nearly meet them for 2035. This outlook suggests that Victoria's emissions targets are achievable if the objectives under the ISP are met, with some additional abatement required by 2035, most likely from the road transportation sector which, while it sees significant change with 2.2 million BEVs/PHEVs on the road by that date, sees overall emissions from road transportation remaining quite high, in part driven by the overall growth in Victorian vehicle numbers.

Table 3-5. Victoria's Greenhouse gas emissions forecast to 2035 under ISP and GSOO assumptions (SEAM base case modelling outputs)

Victoria's Greenhouse Gas Emissions (mt CO_2-e)	2023	2025	2030	2035
Loy Yang A	14.1	15	8	-
Loy Yang B	9.07	8	4.06	-
Yallourn	11.94	10	-	-
Gas Plant	1.70	0.1	0.2	0.8
Total Electricity	36.8	33.8	12.3	0.8
Other energy production (e.g. oil)	1.4	1.2	1.0	0.7
Residential and Commercial	7.7	7.7	5.2	4.3
Industrial	4.2	4.2	4.1	3.2
Construction	0.7	0.7	0.6	0.6
Primary industry	1.0	0.9	0.9	0.9
Direct combustion	13.5	13.6	10.9	9.5
Fugitives	1.6	1.3	1.1	0.8
Civil aviation	0.9	1.7	1.5	1.5
Road transportation	16.4	18.5	18.8	15.8
Railways	0.4	0.4	0.5	0.5
Navigation (maritime usage)	0.3	0.3	0.3	0.3
Other Transportation (freight)	0.0	0.1	0.1	0.1
Total Transportation	18.0	21.0	21.2	18.2
Industrial processing	3.7	3.6	3.1	2.5
Waste	3.0	3.1	2.7	2.2
Agriculture	16.5	16.4	17.0	17.3
LULUCF	-9.3	-11.1	-9.4	-12.3
Total	85.2	82.9	60.0	39.7
Emissions targets		*79-85*	*59-65*	*24-36*

3.2.1.2 Key variables and assumptions

The focus of this report, and of the ISP, is on the electricity sector and the two sectors that the electricity sector helps to decarbonise over the period, transport and direct combustion (through the role played by gas). The variables listed below focused on these three key sectors.

The key drivers impacting Victoria's path to decarbonisation identified through the SEAM modelling are:

- Retirement of three brown coal generators, Loy Yang A, Loy Yang B and Yallourn.
- The capacity factor, or amount of the time, which the remaining gas fired generators are run to provide firming power to the Victorian electricity grid.
- Rate of electrification of residential, commercial and industrial gas load.
- Blending of renewable hydrogen in Victorian gas networks for use by Tariff V (residential and commercial) and Tariff D (Industrial) gas customers as per the GSOO (AEMO, 2024b).
- Growth in the number of BEV and PHEV vehicles on Victoria's roads.

Coal retirement

Currently brown coal fired generators account for about 35 Mt CO_2-e in Victoria. Their retirement dates are therefore crucial in reducing Victoria's carbon emissions. The ISP currently has all three generators retired by the end of the 2033 financial year, and yet Loy Yang B can technically operate until 2047 and Loy Yang A has an agreement with the Victorian government to operate to 2035 (Victoria State Government, 2023b).

Several of the risks identified in this report can be quantified in terms of their impact on these expected retirement dates. This includes risks regarding offshore wind development delay (VH2), peak and annual gas supply shortfalls (VH4), delays to major transmission projects (VH8) and onshore variable renewable energy (VRE) and clean dispatchable resources (H10).

Gas fired generation capacity factor

Gas fired generation capacity in Victoria performs a firming capacity balancing role. Gas fired generation, in the absence of alternatives, provides peaking energy If there is insufficient brown coal fired capacity, and in future, if there is insufficient storage capacity in form of hydro or large-scale battery capacity. This can be particularly important where demand is more variable, or where in some years weather patterns reduce the amount of renewable energy available to the grid as a whole.

For this reason, AEMO, in the Victorian Gas Planning report (AEMO, 2024e), shows a wide range of potential gas consumption in gas fired generators in the near future, ranging from as low as 1-2 PJ in any year, to in excess of 20 PJ. This variance in operation can have a significant impact on carbon emissions in any year (AEMO, 2024e). 10 PJ of gas load, for example, would lead to an additional 0.5 Mt CO_2-e of emissions. (Gas has an emissions factor of 51.53 kg CO_2-e /GJ).

Assessing the changing operation of gas fired generation based on the range of gas consumption forecasts in the GSOO and VGPR, versus the assumed base case, links to a number of potential risks identified in this report. This includes more frequent extreme weather events (H6) (with gas providing firming power where needed), lost energy through the curtailment of VRE resources (H2), households not improving energy efficiency in the home (H3), increases in coal fired generation outages (H5) and EV charging profiles being peakier than anticipated in the ISP (H9).

Electrification

Electrification of gas load, and replacement of gas appliances with electric, results in a reduction in gas consumption. In AEMO's 2024 GSOO, electrification is seen to reduce gas demand by a total of 38 PJ by 2030 and 68 PJ by 2035. As noted above, every 10 PJ of reduction in gas consumption in Victoria accounts for 0.5 Mt CO_2-e of carbon emissions.

Renewable gas blending

Replacement of gas with renewable hydrogen or other renewable gases reduces gas load by the equivalent energy displaced. In the 2024 GSOO, AEMO reflects hydrogen gas blending volumes of 1.8 PJ by 2030 and 9.6 PJ by 2035.

EV uptake

AEMO's ISP sees 2.18 million BEV and PHEV vehicles on Victoria's roads by 2035. (AEMO, 2023b) A significant increase from the figure AEMO reports for the end of the 2023/2024 financial year, 45,548 vehicles.

Typical internal combustion engine passenger vehicles in the SEAM modelling are assumed to produce 2.2 tonnes of CO_2-e per annum, where they travel an average of 13,000 km per annum and use 7 litres of petrol per 100 km. As such, if the BEV uptake is less than the ISP by 100,000 vehicles for example, this would account for an increase in Victoria's carbon emissions of 0.2 Mt CO_2-e in that year.

Summary

The SEAM modelling applies these key variables outlined above to the material risks identified to arrive at a potential net emissions impact figure. For example, if the extent of gas load electrified is less than anticipated, and gas load is 5, 10, or 15 PJ higher than anticipated by 2035, this carries an emissions impact. This emissions impact, in each year, is equivalent to the additional gas load multiplied by the emissions factor of gas consumption. In this case underachieving on electrification forecasts by 10 PJ in any single year would lead to an increase in associated emissions of 0.5 Mt CO_2-e. These outputs were used to quantify risks.

3.2.2 PLEXOS

3.2.2.1 Modelling scenarios

PLEXOS is an industry software used to provide a representation of the operation of the NEM. For any given set of assumptions on future demand, future generation capacity, and the future network, it provides a forecast of the operation of all generating plants in the NEM, and Victoria, as well as market prices, emissions, and any potential issues in relation to security and reliability.

The outputs of the PLEXOS modelling include capacity build in Victoria, prices, emissions and unserved energy. These outputs are then used as additional evidence to support the 'Very High' or 'High' risk scoring for the risks modelled, and to provide insights into the consequences of the risk occurring. The modelling results are described in **Section 3.3**

A base case is created in PLEXOS which reflects all known generating plant in the NEM, recently committed projects, and the forecast of future generating capacity, transmission capacity, and demand provided by the 2024 ISP. The base case model is a continuous, multi-year model that includes 2024 to 2035.

A select number of additional key scenarios are also tested as outlined in **Table 3-6.** To model the scenarios the specific variables in the base case model are updated to reflect the risk being investigated, and the model is then run for the years 2030 and 2035 to test the impact on emissions, affordability and reliability for those years of interest to this study.

Table 3-6 PLEXOS modelling scenarios

Scenario	Purpose	Key modelling assumptions
Base case	Helps to show the extent of the VRE curtailment, the extent of gas energy needed from which sensitivities on VRE (dark lull) can be completed off-model.	Model inputs based on figures from the AEMO DRAFT 2024 ISP Input and Assumptions Workbook.
Offshore wind development delay	Helps to test the both the impact of transmission development delays and delays in the development of offshore	Victorian Government offshore wind targets are 2 GW by 2032, 4 GW by 2035, 9 GW by 2040.

	wind generation assets. They are both tested through a delay in the availability of offshore wind to the NEM (that may be through a delay in transmission or the offshore generation itself).	Model assumed 2 GW of offshore wind is available in 2036 only.
Coal retirement delay (in response to offshore wind development delay)	To test the impact of delay in coal retirement due to delays in the build of major transmission projects and the build in offshore wind generation.	Loy Yang B retirement delayed from the assumed retirement date in the step change scenario in the ISP.
Delay to Marinus Link	Used to test delayed transmission impacts.	Stage 1 and 2 delayed post 2035.
Increase in generation plant outages	Used to test coal fired power outages and wider outages across the system.	Outage rate increased by 2% for coal plant.

3.2.3 Key risks and their impact observed in the modelling

Key variables driving emissions reductions are identified in **Section 3.2.1.2.** These variables influence emissions reductions objectives in the electricity sector through the retirement of brown coal, and the operating capacity factor of the remaining gas fired power stations. The variables also have a bearing on the degree of electrification achieved, the take up of zero emissions vehicles in Victoria and blending of renewable gases in Victorian gas networks.

Impact on emissions

The emissions impact analysis is conducted primarily in SEAM, with support from PLEXOS runs, which also provides insights into impacts to affordability and reliability.

Emissions impacts across each of the High and Very High risks are described where they can be quantified or tied to one of the key variables identified. The key risks identified in the modelling, shown in **Table 3-7** below, range in emissions impact from 0.25 Mt in any year to 20 Mt in any year.

Severe impacts are driven by changes to the timing of brown coal retirement which have a significant impact in 2030 and 2035. This key risk variable describes the quantum of emissions risks associated with thermal power plants being run longer than expected in the ISP and a number of risks that would more than likely drive delays in thermal coal retirement, these include:

- Offshore wind development targets not being met
- Shortfalls of gas for peaking or annual operation
- Transmission delays
- Issues with the development and funding of onshore VRE and clean dispatchable resources.[5]

[5] The risk 'Development and funding risk for onshore VRE and clean dispatchable resources' is a collective risk across a large number of projects, as opposed to a risk across a smaller number of very large projects as in the case of offshore wind. While the collective overall emissions impact of this risk could be rated as severe, as the risk is spread across numerous individual project developments over time, it has been rated as a high risk.

Table 3-7. Estimated increase in emissions as a result of identified risk occurring. Colours denote significance of emissions to achieving 2030 and 2035 emissions reduction targets

Risk ID	Risk Event	Risk Rating	2030 Mt CO2e pa	2035 Mt CO2e pa
VH1	Thermal power plants are run longer than expected (as per ISP)	Very High	3-20	3-20
VH2	Offshore wind targets not met	Very High	0	3-20
VH3	More frequent extreme climate weather events increase frequency and unpredictability of peak demand events	Very High	0.25-1	0.25-1
VH4	Peak and annual gas supply shortfalls	Very High	3-20	3-20
VH5	Existing gas customers don't electrify to the anticipated level per the ISP	Very High	0.2-1	0.4-2
VH6	Lack of renewable gas developments	Very High	0.1	0.5
VH7	Consumers uptake of battery electric vehicles (BEV) and plug in hybrid electric vehicles (PHEV) not high enough to achieve emissions objectives	Very High	0.1-0.2	0.4-1.2
VH8	Major transmission project delays (Marinus Link, VNI West, V1-V8 REZs, Western VIC, Eastern VIC)	Very High	3-20	3-20
H1	Inadequate management of additional loads and flows on distribution networks	High	0.2-1	0.4-2
H2	Curtailment of VRE resources due to low minimum demand levels	High	0.25-1	0.25-1
H3	Households do not improve energy efficiency of their homes to reduce their electricity load	High	0.25-1	0.25-1
H4	Lack of customer take up of embedded and aggregated storage	High	0.25-1	0.25-1
H5	Increase in coal fired power outages	High	0.25-1	0.25-1
H6	Extension of fire season reduces generation and transmission reliability, extreme weather impacts transmission reliability	High	0.25-1	0.25-1
H7	Inadequate long duration storage in time for coal exit	High	0.25-1	0.25-1
H8	Spiralling gas network costs for remaining gas consumers.	High	N/A	N/A
H9	EV charging profile is peakier than anticipated in the ISP	High	0.25-1	0.25-1
H10	Development and funding risk for onshore VRE and clean dispatchable resources	High	3-20	3-20

Major impacts are driven by the degree of electrification achieved in Victoria, or the amount of emissions from direct combustion of gas that are displaced as a result of electrification. This has a bearing on the risk that existing gas customers don't electrify to the anticipated level in the ISP. In **Table 3-7**, the ranges are driven by an assumption that electrification is 10%- 50% below the levels assumed in the ISP. Some of the obstacles to electrification illustrated by Grattan in their report on Getting Off Gas, imply that a risk range this wide may be appropriate given the obstacles experienced by more than 50% of Victorian consumers in moving off gas (Figure 2.6 in Grattan's report, shown in the figure below) and the asset life of gas assets being such that as Grattan note "a gas water heater installed today will still be burning gas in 2035". This range is chosen to illustrate the impact of under achieving on this target as a consequence of these key factors (Grattan Institute, 2023).

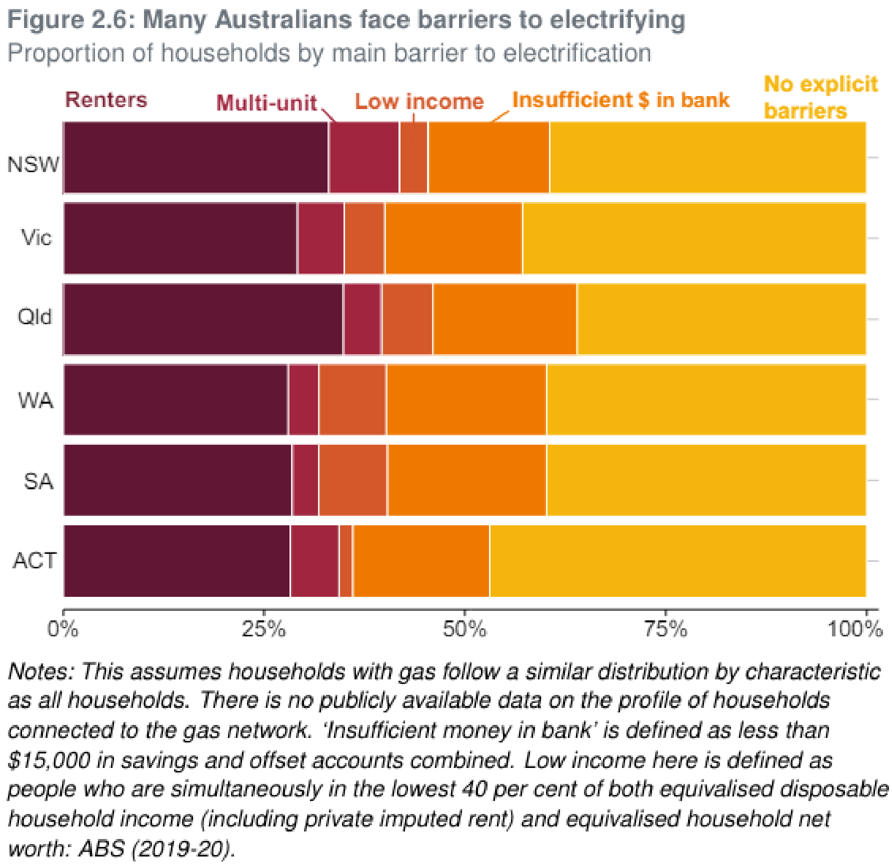

Figure 4-3 Many Australians face barriers to electrifying (Wood, Reeve & Suckling, 2023)

A lack of renewable gas developments is rated as a very high risk because of the potential greater impact on emissions post 2040. The impact in 2035 shown in table 3-7 reflects the risk that hydrogen uptake does not meet the levels observed in AEMO's GSOO. In the longer term, hard to abate uses of gas for industrial consumers that cannot electrify, would likely see renewable gases playing a greater role in emissions abatement than is observed earlier in the outlook,

The impact of inadequate management of additional loads and flows on distribution networks is modelled, through its impact on measures to increase electrification, but could also be measured through its impact on the take up of other consumer technologies, such as rooftop PV or EVs.

Major impacts are also driven by the operation of the gas generation fleet and the key risk variable to emissions of how much or how little gas fired generation operates in any year. Gas will tend to run harder to supply peak energy, or unexpected peaks in energy requirement, or troughs or shortfalls in energy supply from renewables. This has a bearing on a number of risks including:

- More extreme weather events (with higher peak demands needing to be supplied by firming gas capacity) (VH3)
- Curtailment of VRE resources (lack of energy) (H2)
- Lack of energy efficiency measures (requiring more energy supply as a whole and more peak energy supply) (H3)

- Lack of customer take up of embedded storage (peakier demand profiles) (H4)
- Increases in coal fired power outages (leading to unexpected shortfalls of energy particularly during peak periods) (H5)
- Reductions in generation and transmission reliability (H6)
- A lack of long duration storage alternatives (H7)
- EV charging profile being peakier than expected (H9)

Major impacts are driven by the number of zero and low emissions vehicles on Victoria's roads. In this case, the risk variable used is the difference in emissions between a typical ICE vehicle, travelling 13,000 km a year, using 7 litres per 100 km and emitting 2.2 t CO_2-e per annum and a zero emissions BEV. This variable is used to assess the impact of the risk that consumers uptake of BEVs/PHEVs is not enough to meet emissions objectives. In this case the range of risk shown varies between 10-30% under achievement versus the ISP objective. The Victorian Governments target of 50% of light vehicles sales to be ZEVs by 2030 might, depending on the rate assumed pre and post 2030, the amount of PHEV sold and the amount of larger zero emissions sold, lead to an under achievement of about 20%. This range is broad however and is chosen here for illustrative purposes. Effectively every 100,000 BEVs sold below target would lead to 0.2 t CO_2-e more emissions from road transportation in Victoria, assuming the EVs are replacing, or displacing an ICE vehicle.

Impacts to affordability and reliability

As noted in **Section 3**, a base ISP case has been modelled in PLEXOS as well as four additional counterfactual scenarios in which some of the key risks identified are seen to eventuate and are tested in the model, in terms of their impact on emissions, price or affordability and reliability or the amount of unserved energy observed in that scenario. The wholesale spot market price changes in these counterfactual scenarios are illustrated in **Figure 3-1** below. Wholesale price impacts will have a bearing on the overall bill paid by consumers.

Figure 3-1 Price and affordability impacts of alternative scenarios (PLEXOS)[6]

A summary of the impacts observed from risks to affordability and reliability[7] are shown in **Table 3-8** based on analysis of the ISP in PLEXOS. Risks to affordability are assessed in terms of whether material changes are observed in wholesale electricity costs. Risks to reliability are observed in terms of whether material changes are observed in unserved energy levels in the risk scenarios versus the base case. This analysis, in addition to the SEAM analysis, supports the categorisation of risks in the very high and high category. In all cases, bar spiralling gas network costs, the emissions impacts observed are material, and as noted above where modelling was able to be conducted, major impacts to affordability and reliability were also observed for key risks. Reliability was measured through changes to expected levels of unserved energy in the different scenarios.

[6] Note: OSW – Offshore wind, LYB – Loy Yang B

[7] To gain numerical insights to the impact category 'Reliability, Security and Safety', the PLEXOS model provides reliability data based on unserved energy. This information is used to support the severity of the risk rating under the 'Reliability, Security and Safety' category. A "major" reliability impact means that a risk event may result in an expected breach of the reliability standard in any year. The reliability standard specifies a maximum expected unserved energy in the region of 0.002 per cent of the total energy demanded in that region for a given financial year (AEMC). In the event of a delay in a project and a potential exceedance of the reliability standard, it is likely that other actions, e.g., use of gas generation, would be implemented to avoid the breach of the standard, with a consequent impact on emissions and affordability.

Table 3-8 Affordability and reliability impacts of material risks

Risk ID	Risk Event	Impact on affordability	Impact on reliability	Key observations from the modelling
VH2	Offshore wind targets not met	Major	Major	The results demonstrated that while offshore wind targets not being met or VRE resources being developed behind schedule have impact on emissions, it also leads to increases in prices and a potential threat to the reliability standard in 2035.
H10	Development and funding risk for onshore VRE and clean dispatchable resources	Major	Major	
VH1	Thermal power plants are run longer than expected (as per ISP)	Beneficial	Beneficial	Where coal fired power station retirement is delayed in response to offshore wind targets not being met or VRE resources being developed behind schedule, this has a negative impact on emissions, but might in isolation lead to lower wholesale spot prices, and greater reliability in the short term. Wholesale spot prices are seen to be on average 24% lower in the case where brown coal retirement is delayed (Figure 3-1 above). These stations however would be unlikely to be operating profitability through this period, with a consequent cost for the operator and/or governments.
VH8	Major transmission project delays	Major	Minor	Delays to the Marinus link project have a variable impact on prices in different years depending on the net direction of flow[8].
H5	Increase in coal fire power outages	Major	Major	Increases in coal fired power outages lead to a 50% increase in wholesale prices and potential threats to reliability in some years.
H7	Inadequate long duration storage in time for coal exit	Major	Major	Long duration storage is limited when coal exits the NEM in the ISP in 2033. Depending on weather and demand patterns in particular years this may see high prices in 2035 and also threats to reliability. This is observed through price and reliability changes in the base case post brown coal retirement.

3.3 Analysis

This section outlines further analysis of the risks, including the frequency of causes across the risks and a discussion on risk interconnections.

[8] The timing of Marinus, versus the timing of all other projects in the NEM, will mean that the net direction of flow (i.e., power tending to flow from Tasmania to Victoria) may vary. To the extent flow is balanced between the two regions, the price impact of not having Marinus in any year will be less pronounced. Over the longer term (or in particular years), the flow may be predominantly from Tasmania to Victoria which would see much higher impacts from Marinus not being available.

Cause interconnections

As shown in **Figure 3-2**, the most commonly recurring themes of risk causes (as defined in **Appendix B Risk Model Development**) identified in this assessment are technology, supply chain issues and community acceptance followed closely by issues of investment and economics. More detail on the causes for each risk can be found in the risk register in **Appendix D Risk Register.**

Technology factors are a key contributor to the risk of inadequate long duration storage in time for coal exit and also influence other risks including the delivery of major transmission and offshore wind projects, lack of renewable gas developments and the capacity of the electricity distribution network to manage additional loads due to the rise of new technologies (e.g., rooftop solar).

Risks that rely on consumer behaviour change, include customer uptake of embedded and aggregated storage, and rates of electrification. In the transport sector, behaviour change is a key cause of risks relating to consumer uptake of electric vehicles and the potential peaky charging profiles of electric vehicles.

Community acceptance can have a major influence on major infrastructure project delivery required to enable the energy transition including on and offshore wind, and transmission network expansion to facilitate renewable energy zones.

Supply chain issues are seen as key causes of the risks to delivering major infrastructure projects and ranges from the availability of a skilled workforce to suitable ports being identified for offshore wind projects.

Issues around investment and economics affect most of the very high rated risks, and cover issues ranging from the provision of capital investment for major projects through to decisions made at the household level on energy efficiency upgrades.

Understanding key causes support the development of mitigation strategies to reduce the risks. Opportunities to effectively address causes that potentially influence multiple risks are explored in **Section 4.**

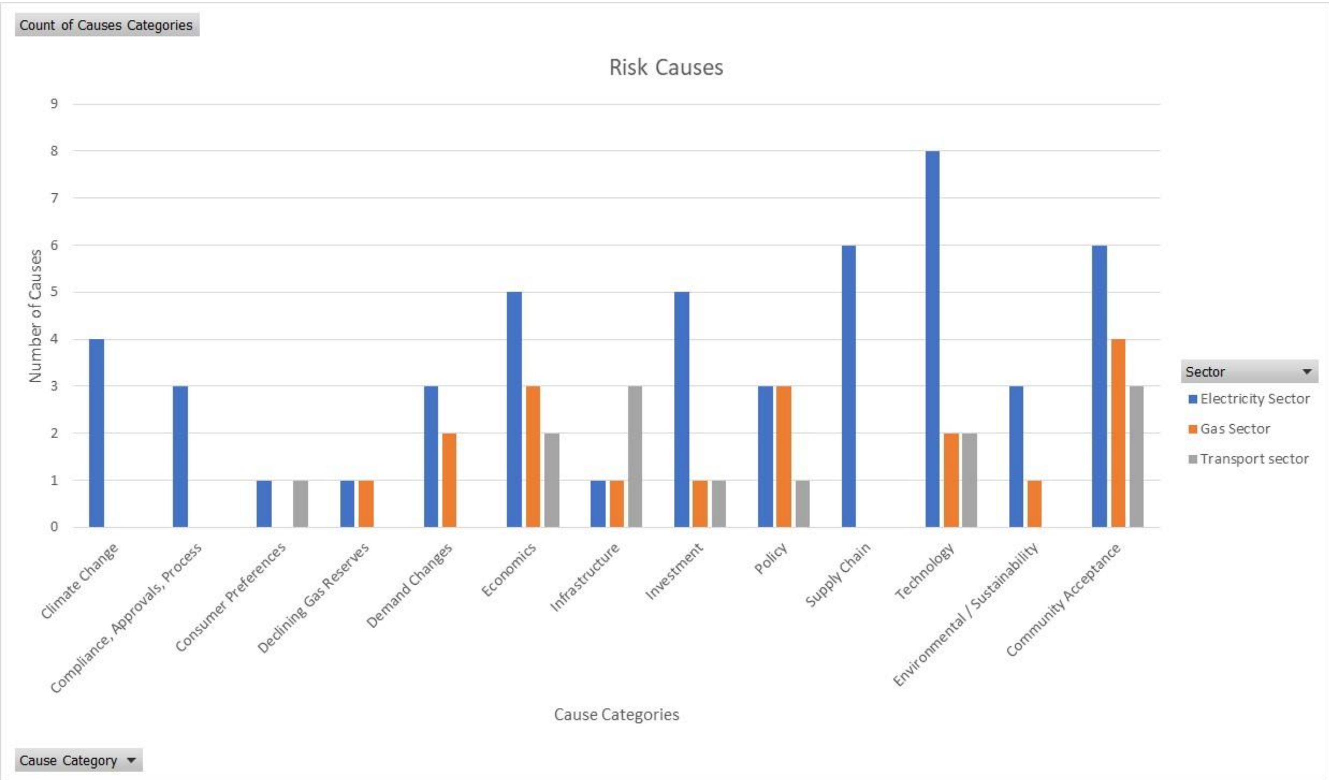

Figure 3-2. Cause analysis

Risk interconnectivity

In **Figure 3-3**, the relationships between key risks are shown. The risks can be clustered according to four key areas: the transition off coal, the transition in the customers use of energy, the transition of the vehicle fleet and transitioning customers off gas.

There are important interconnections between these the four key risk themes. In particular, electricity distribution networks play a central role in facilitating the transition off fossil gas, the transition of customers use of energy and the transition of the vehicle fleet to electric. A high risk has been identified of 'H1 Inadequate management of additional loads and flows on distribution networks which connects all four risk themes.

Certain risks have a cluster of risks around them leading to an increased likelihood of occurrence. The risk that thermal plants will run longer than expected (VH1) has a number of other risks that lead into it including offshore wind targets not being met (VH2), development and funding risks of onshore VRE and clean dispatchable resources (H10) and inadequate long duration storage (H7) all contribute to the likelihood of thermal plants running longer than expected.

Some risks have varied impacts on other risks. For example, if electrification targets are met (linked to VH5), this will have a beneficial impact on the risk of annual and peak gas supply shortfalls (VH4) by reducing the likelihood that this occurs and the severity of the impact. It will also, however, heighten the risk that distribution networks are not augmented, or managed, in a timely fashion to accommodate the additional load or flows on the system (H1) and contribute to the likelihood that there are spiralling gas network costs for remaining gas consumers (H8).

This risk interconnectivity helps in supporting the materiality assessment, or likelihood of risks, and can help to inform the choice of mitigation actions in dealing with the risks identified.

Noteworthy considerations

As part of the impact analysis and stakeholder workshops, social, environmental and governance (ESG) causes and impacts were identified and considered. For example, the ESG considerations and impacts (which are further detailed in in **Appendix D Risk Register**) associated with specific risks included:

- VH1Thermal power plants are run longer than expected (as per ISP): Beyond exceeding emissions targets, this risk contributes to ongoing climate change and its associated widespread adverse impacts to nature and people and also contributes to other ongoing negative environmental impacts associated with running thermal power plants such as air quality impacts.
- H3 Households do not improve energy efficiency of their homes to reduce their electricity load: Energy poverty disproportionately affects vulnerable populations, including low-income households, the elderly, and people with disabilities. Inadequate policies perpetuate social inequities, as those who can least afford high energy costs bear the brunt of inefficiencies. Inadequate energy efficiency can directly affect residents' health and well-being. Poor insulation, inadequate heating, or lack of cooling can lead to uncomfortable living conditions. Cold homes can contribute to respiratory illnesses, exacerbate existing health conditions, and impact mental health.
- H10 Development and funding risk for onshore variable renewable energy (VRE) and clean dispatchable resources: There is an inherent conflict between the need to build new infrastructure versus ongoing protection of biodiversity and ecological values which continues to impact energy infrastructure projects and has a flow on effect to community acceptance.

The importance of governance and regulatory structures to manage and mitigate ESG risks and facilitate decision-making in support of energy transition targets is critical. This will, for example, support clear assessment and communication of potential and likely environmental impacts associated with energy infrastructure developments and the application of measures to minimise impacts. Additionally, ESG factors are increasingly shaping decision making in investment, evaluation and development of renewable energy developments. Project developers and investors' ability to integrate ESG factors and positive outcomes into their projects may impact their ability to access private funding/investment.

In addition, it is important to highlight the First Nations support for and partnership in the clean energy transformation as a key priority under the National Energy Transformation Partnership. Development of the First Nations Clean Energy Strategy is underway (as of April 2024) and will include ensuring First Nations self-determining rights, perspectives, views and decision-making are integrated into energy and climate change policy-making and program development in Australia. Also noted is Victoria's commitment to Treaty, which advances Aboriginal self-determination (Department of Premier and Cabinet, Treaty for Victoria) which needs to be considered in the development of all policies and programs associated with the energy transition. A risk was identified during the analysis of First Nations Clean Energy Strategy not being implemented to the degree anticipated. This risk has been rated as medium, rather than high or very high, with an assessment given of a potentially major impact on social equity and emissions, and the likelihood of the risk occurring as 'possible'[9].

[9] Refer to **Appendix B Risk Model Development** for more information on the risk model and ratings.

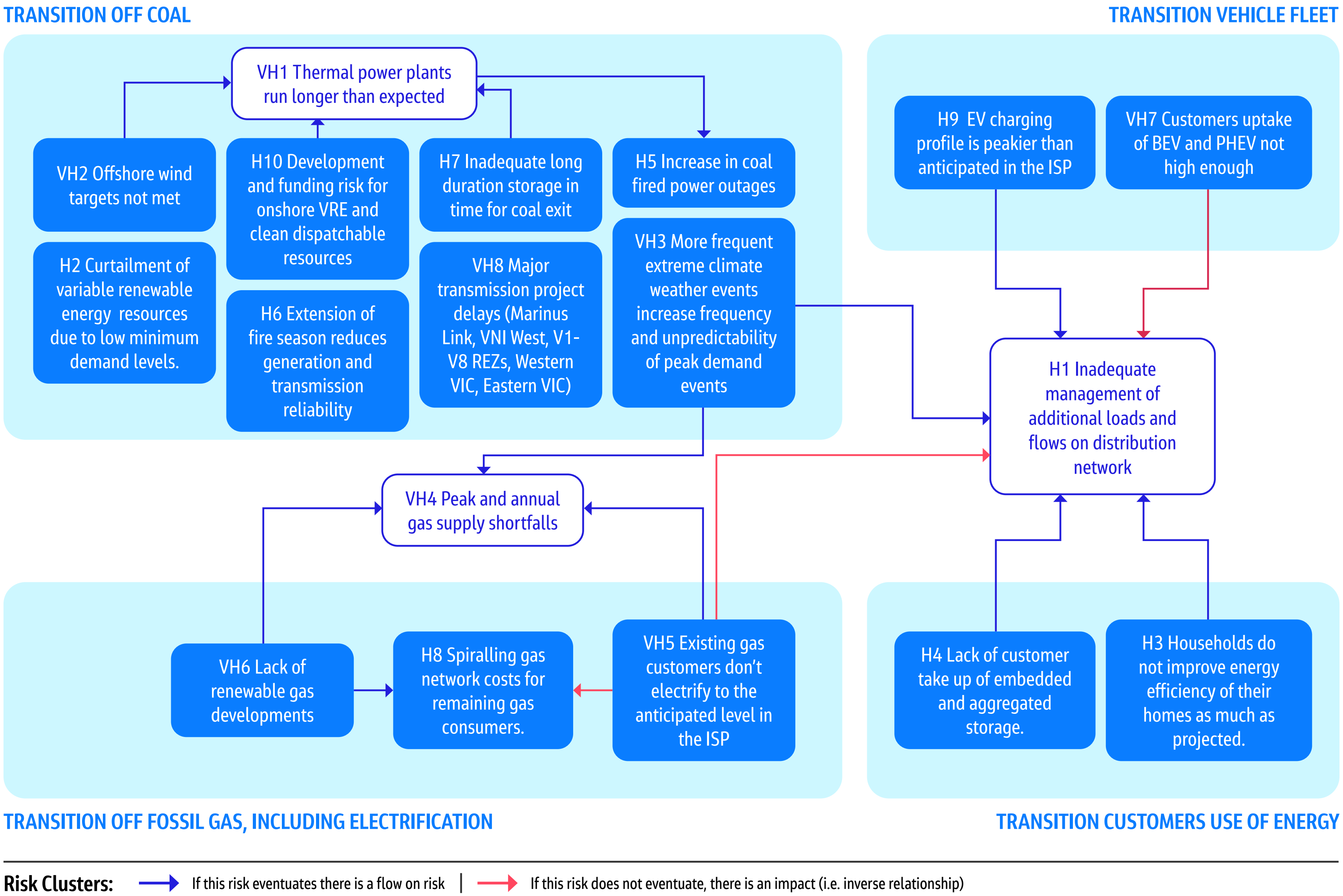

Figure 3-3. Interconnectivity between highly rated risks

3.4 Summary of risk analysis

The greatest changes in emissions in Victoria's path to a low carbon future carry the greatest risk. The outcomes of the risk analysis focus on these key areas. They are also driven by analysis of the programs that are in place to help achieve those emissions reductions goals in the timeframe. Modelling of the risks in SEAM and PLEXOS has helped to inform the key drivers of risk, and the consequences for emissions, affordability and reliability. Engagement with key stakeholders has further assisted in supporting or challenging the assumptions and outcomes of the analysis undertaken, as well as identifying the key areas of focus for governments.

The analysis of the risks, highlighted four key risk themes in Victoria's energy transition, focusing on areas where significant emissions reductions are anticipated. These four key risk areas are as follows:

1. **Transition from coal to renewables.**

- The timely retirement of brown coal capacity and the development of significant variable renewable energy (VRE) resources, particularly in the form of offshore wind, sees some of the greatest risks to emissions reductions. As identified in the Progress Analysis (**Section 2.2**), there is a gap between the observed closure dates in the ISP step change scenario and the current planned retirement dates of brown coal generation in Victoria. The SEAM modelling identifies changes in brown coal generation retirement dates have the largest overall impact on the achievement of Victorian emissions objectives in 2035, with an estimated increase in emissions (of thermal power plants running longer than expected (as per ISP)) of between 3-10 MtCO_2-e per annum by 2035 (**Table 3-7**).
- Delays in the build of VRE and dispatchable resources threaten the affordability and reliability of energy supply in 2030 and 2035 (**Table 3-8**).
- Other key risks that result in affordability and reliability impacts include whether there will be inadequate long-duration storage in time for coal exit and the risk that major transmission developments are not delivered on schedule (**Table 3-8**). This was supported by both rounds of stakeholder engagement, particularly in relation to the question of long duration storage, which was seen as addressing a gap in existing programs and having a high impact on the risks associated with brown coal retirement.

2. **Transition off fossil gas.**

- Electrification plays a significant role in Victoria's future, as a means of reducing emissions from the combustion of gas and taking pressure off a tight supply demand balance in Victorian gas markets. Many of the risks associated with electrification can be linked to decisions made at the household or business level.
- The path to electrification in Victoria is challenging, particularly by the 2035 timeframe. Gas devices have an expected useful life that will see many continue to operate for the next 12-15 years, and many households may be restricted in the decisions they can make on those devices when they come up for replacement.
- Further, there are significant risks that existing gas customers are not sufficiently aware, incentivised or able to switch to electric. The gap analysis highlighted the extent of the task that lies in front of Victoria in electrifying a large portion of its gas load before 2035 given the lifecycle of gas devices, and the required conversion rate needed to meet electrification goals.
- The SEAM modelling identifies that for every 10 PJ of gas load not reduced through electrification, emissions in Victoria will be 0.5 mt CO_2-e higher in 2035, thereby putting the achievement of emissions reductions goals at risk (**Table 3-7**). Engagement with key stakeholders further informed the importance of this risk.
- Gas fired thermal generation is currently the most flexible source of firming/dispatchable peaking power in the National Energy Market (NEM) at scale. Assuming it continues to play a key role in providing flexible

firming power out to 2050, events that lead to greater usage of gas have a consequent impact on emissions in the NEM. These events include the variability of demand due to extreme weather, issues with the reliability of other thermal plant, either due to weather or the ageing nature of those assets, as well as any changes in load over time that add to peaking electricity load. The management of these changes in other ways, for example through the load profile of EV charging, or through additional embedded generation at the customer level, or through new long duration storage technologies, will have a bearing on these risks and the extent of the role gas continues to play in the transition.

3. **Transition customers use of energy.**

- Two high risks were identified relating to consumers use and storage of energy (H3 and H4). A lack of action and investment in relation to energy efficiency measures could increase emissions or lead to missed opportunities to avoid emissions and has been identified as a possible gap in programs (**Section 2.2**). Engagement with key stakeholders confirmed that energy efficiency is seen as a key risk and mitigation factor given its ability to have a rapid impact across several key areas including risks for supply, storage and transmission.
- A lack of customer uptake of embedded and aggregated storage can lead to a slow- down in the penetration of rooftop PV, for example, with technical limitations at network level leading to reduction or delay in low emissions consumer resources being deployed. This was identified in the gap analysis where current rates of take up of embedded storage fall short of the rate required to match the embedded storage capacity assumed in the ISP by 2035. A lack of take up of embedded storage would potentially mean a higher cost at the network level to integrate more electric devices and more EVs into the electricity grid.

4. **Transition vehicle fleet.**

- The transition of the vehicle fleet to electric propulsion is the key mechanism to decarbonise the transport sector. The gap analysis identified the key risk that the projections in the ISP for the uptake of low and zero emissions vehicles (2.2m by 2035) will not be met based on the current trends. In addition, the overall projected growth in the Victorian passenger fleet, as modelled in SEAM, indicates a potential need to go beyond the numbers set in the ISP for zero and low emissions vehicles in order for Victoria to meet its broader emissions goals. Victoria may need to target more than the 2.2m PHEV and BEV vehicles by 2035 observed in the ISP step change scenario, to meet its ambitious climate goals. This would have a consequent impact on electricity demand.

There are important interconnections within and between the four key risk themes, as highlighted by **Figure 3-3**. There are several key risks that influence the retirement of brown coal generation on schedule, including the timing of the build of new renewable generation, including offshore wind, and the development of long duration storage options in time for coal's exit to ensure the Victorian system has adequate resources to match supply with demand over the course of the transition.

The removal of Victoria's reliance on fossil gas for peaking annual energy supply, through electrification, renewable gas developments and other measures, plays a critical role in decarbonising the gas sector but also managing concerns regarding the security of gas supply over coming years. There may be an increasingly variable demand for electricity in future with the continuing and growing impact of climate change on demand patterns, and this will have an impact on gas demand patterns in future.

Of particular note are the electricity distribution networks which play a central role in facilitating the transition off coal, off fossil gas, with the transition of customers use of energy and the transition of the vehicle fleet to electric. A high risk has been identified of 'H1 Inadequate management of additional loads and flows on distribution networks which connects all four risk themes.

Social equity impacts and consequences across these four key risk areas include:

- Flow on impacts from the transition off fossil gas. For example, certain gas consumers are exposed to the risk of spiralling gas network costs, for example, where large numbers of consumers are able to make the switch off gas and onto electric, some may be left behind.
- There are potential affordability impacts from the transition from coal to renewables, where there is a greater reliance on gas generation in some years.
- There are equity issues in relation to the transition away from gas, in that many households may not be in position to make the financial decision to switch from gas to electric devices.
- There are potential socially inequitable impacts from the customers transition in the use of energy, as those who are unable to invest in energy efficiency measures are often those who can least afford high energy costs and thus bear the brunt of inefficiencies.

4. Mitigation of the Very High and High risks

Following the identification of the key risks, this project considered, 'What actions, strategies and/or measures can the Victorian Government take to mitigate or minimise these risks to achieving the energy transition?'.

Mitigations can either reduce the likelihood of a risk emerging or reduce the impacts of it when it does occur. This analysis has sought to identify actions the Victorian Government could take now to address the highest risks to the transition. The identified mitigation actions respond to the causes and consequences of the risks, with the intention of reducing the likelihood of the risk event occurring or the severity of the impact should it occur, on emissions, reliability, security and safety, affordability and social equity.

A range of different mitigation actions to address the risks have been considered, ranging from education awareness campaigns to delivering new skills training programs to build a future-ready workforce, to government investment in subsidy programs for renewables infrastructure to improve investor confidence. In most cases, the key risks have multiple causes and impacts, so a suite of mitigation actions may need to be deployed to effectively reduce the risk rating.

For the purposes of this assessment, mitigation categories have been designed that respond to the specific energy transition risk causes and impacts identified in this assessment. Under each mitigation category, a range of specific actions are considered. Rolling up similarly themed actions into categories provides a comprehensive high-level approach and assists with both communicating the mitigation actions being considered and effectively assessing and prioritising the actions.

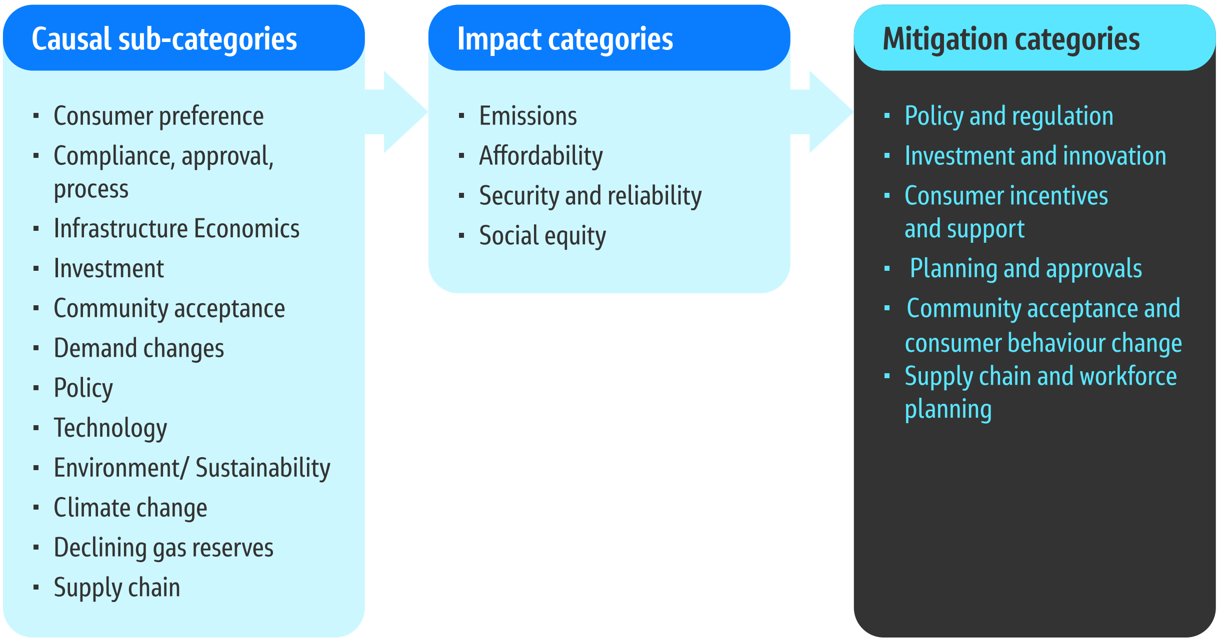

Figure 4-1. Mitigation actions respond to the causes and the impacts of the risk events

4.1 Overview and Approach

The risk analysis identified four key areas of focus on Victoria's pathway to a low emissions future. These areas centre around the greatest potential sources of emissions reductions between now and 2035. They are the transition from coal generation, the transition off fossil gas (including electrification of gas loads), transition of customers use of energy and transition to an electric vehicle fleet. According to State Greenhouse Gas Inventory data, these categories made up around 82% of net emissions in Victoria in 2021 (51% for electricity, 23% for road transport and 10% for combustion of fossil gas in the residential and commercial sectors) (**Table 4-1**, DEECA, 2023l).

Table 4-1 Net emissions in Victoria 2021 (DEECA,2023l)

Sector	Emissions (Mt CO_2-e)			
	2005	2021	% change	**% of 2021 total**
Land use change	-11.3	-21.1	87%	**-26%**
Agriculture	15.8	16.4	4%	**20%**
Electricity	63.5	41.7	-34%	**51%**
Other energy creation	3.3	2.6	-20%	**3%**
Residential/commercial direct combustion	8.2	8.1	0%	**10%**
Other direct combustion	7.1	6.8	-4%	**8%**
Transport	20.2	18.6	-8%	**23%**
Fugitive	2.4	1.7	-26%	**2%**
Industrial processes	2.8	3.9	40%	**5%**
Waste	4.2	2.7	-34%	**3%**

The mitigation actions cluster around these focus areas and describe actions that help to or manage the impact of the risk during the transition. The actions identified are those that have been qualitatively assessed as having the potential for the highest impact, either in terms of reducing the likelihood of the risk occurring in terms of meeting emission targets or in managing critical issues around reliability, security and safety, affordability, or social equity, in the course of a rapid transition.

Several actions were identified that address risks across all four focus areas, these have been grouped and considered as 'cross cutting actions'.

Analysis of the actions has also helped to identify those areas where there are already existing programs under way or programs under development and has identified areas where there are gaps in the current program, or the challenge is so great in the timeframe that more action is required in order for Victoria to meet its emissions reduction goals.

The following steps were undertaken to identify and assess the mitigation actions relating to the highly rated risks:

- Develop a long list of potential mitigation actions against each of the Very High or High rated risks, allocated by mitigation category. From the long list, evaluate the 'high impact' mitigation actions. This was undertaken using the lens of "which of these have the highest potential impact on the risk, in terms of addressing the likelihood of the risk occurring or the impact of the risk", drawing on quantitative and qualitative evidence from the risk assessment process and further research. The output from this was 21 identified 'high impact' actions (refer **Table 4-3** to **Table 4-7).**
- Stakeholder engagement with representatives from Infrastructure Victoria, the Department of Energy, Environment and Climate Action and the Department of Transport and Planning (**Appendix C Stakeholder Engagement**) involving a workshop to test and gather insights on the 'high impact' actions.
- Further analysis of the 'high impact' actions with consideration of implementation challenges or opportunities (**Section 4.2**).
- High-level overview of residual risks after consideration of the 21 'high impact' mitigation actions (refer **Appendix E Mitigation action assessment)**. The 'high impact' mitigation actions against each Very High and High rated risk are provided in **Appendix E Mitigation action assessment.**

4.2 Mitigation actions and analysis

This section outlines the 'high impact' actions that have been assessed as having the highest potential in addressing the Very High and High rated risks. Each of these actions have been determined as a priority for 2025–2030 (and potentially beyond where noted) with the Victorian Government having a key role in implementation. For each action, implementation considerations are outlined in **Table 4-3** to **Table 4-7** including key points on:

- Whether the action addresses a gap or is an extension of an activity that already exists or is underway
- Implementation challenges and insights
- Potential benefits of the action
- High level cost. An indicative cost range is provided based on a qualitatively assessed scale of potential financial cost to the Victorian Government to implement the mitigation action, as per **Table 4-2.**

Table 4-2 Cost scale for mitigation actions

	Cost range (AUD)	Example actions with reference examples
Low	Less than $10 million	Planning studies or investigations. - Under the Victoria's Zero Emissions Vehicle Subsidy, $298,000 was awarded for an EV-readiness in new buildings study, (Solar Victoria, 2021). - Under the Energy Innovation Fund (DEECA, 2021), $2.3 million was awarded for scoping studies and surveys for a 1.5GW offshore wind farm off the coast of Gippsland
Medium	Between $10 and $100 million.	Funds for the provision of subsidies and grants (targeted programs). - Victoria's Zero Emissions Vehicle Subsidy Program provided individual subsidies at the point of purchase for more than 20,000 EVs under a $46 million fund (Solar Victoria, 2021). - The Victorian Government's Energy Efficiency and Solar Program, supported by a $40 million investment, is supporting public hospitals, aged care facilities and ambulance stations to transition to electric and improve energy efficiency (VHBA, 2023) Funds for communications campaigns - For example, on Cancer Council's analysis, an investment of $20 million per year over three years would pay for a broad sun protection awareness campaign across national TV, radio and digital platforms, with sufficient impact to deliver significant returns in reduced social and economic costs related to skin cancer (Cancer Council, UV Radiation Prevention Policy)
High	Over $100 million	Capital costs of infrastructure development. - A $2 billion dollar wind farm to be built in Victoria involved a $175 million commitment from the Clean Energy Finance Corporation (AFR, 2022). Funds for the provision of subsidies (large programs). - The Australian Government Household Energy Upgrades fund (Clean Energy Finance Corporation), focused on helping homeowners fast track their energy transition, is worth $1billion.

4.2.1 Cross cutting actions

Several actions were identified that address risks across all four focus areas. One of these actions is a broad and sustained public and consumer education campaign, to address the common cause of community acceptance and consumer behaviour change. In addition, a sufficient skilled workforce is required to deliver the transition, both in delivering the pipeline of major infrastructure projects and in supporting consumers to switch from gas to electric. Implementation of a comprehensive workforce investment plan that considers future-focused training programs, apprenticeships and finance to help re-skill the workforce for a renewable electric future was identified as a key cross cutting action. Additionally, reducing overall demand on the electricity network will also reduce the severity of the impact of several risks and should be prioritised alongside actions that support electrification.

Table 4-3 Cross cutting mitigation actions

Mitigation category	Mitigation action	Related risks	Purpose of/need for action	Potential benefit	Implementation considerations, including cost
Community acceptance and consumer behaviour change	Comprehensive and sustained public communications campaign that links all of the transition pieces together.	VH2 VH3 VH5 VH8 H7 H10	One of the common causes for very high and high ranked risks is insufficient community acceptance (e.g., for major infrastructure projects), or consumer behaviour change (e.g., rates of electrification). Sustained public education and awareness campaigns focused on the energy transition goals and benefits have the potential to increase broad public support for major transition projects and influence consumer decisions regarding electrification, EV vehicles and the use of energy in the home.	Increases overall community support and understanding, leading to increased community acceptance and positive consumer behaviour change, thereby reducing the likelihood of multiple risks occurring.	This mitigation action should consider: ▪ Highlighting the links between the need for improved building efficiency, the need to reduce overall demand on the network and why new transmission is needed, so that the public understands the overall aims of the program are to benefit consumers while meeting emissions reduction goals. ▪ Research is important to help define the campaign audience and refine the messages that will resonate. ▪ Communications programs should be long term to build trust and knowledge of the program. (Low et al., 2015). ▪ Clear, memorable and sustained messaging supported by educational materials and multi-media approaches have been successful in sectors such as health (Slip, Slop, Slap campaign by Cancer Council of Australia) and road safety (TAC Driving Tired campaigns). Insights may be drawn from the International Energy Agency (IEA's) advice on how awareness and behaviour campaigns can enable and motivate stakeholders and community to save energy (IEA, 2022a). COST: Medium (assuming a long-term, multi-year/multi-media communications program, supported by research and consumer feedback). Refer to **Table 4-2** for reference.

Mitigation category	Mitigation action	Related risks	Purpose of/need for action	Potential benefit	Implementation considerations, including cost
Supply chain and workforce planning	Implement a comprehensive energy transition workforce investment plan	VH2 VH8 VH5 H10	Around 20 000 to 25 000 new jobs are predicted to be created in Australia in the construction, maintenance and operation of renewable power (IEA, 2022). Planned workforce investment in skills development and training will facilitate sourcing the skilled workers needed to deliver the pipeline of major infrastructure projects associated with the energy transition. Informed and educated sales and tradespeople who understand the key energy transition pathways, options and support available to customers in their sector are required to support proactive consumer decision making in areas such as electrification or switching from gas appliances.	Having sufficiently trained and skilled workers and trainers will improve confidence in being able to deliver the pipeline of renewable energy infrastructure projects, on time, and to budget, thereby reducing the likelihood of the risk of project delays. Well-informed sales and tradespeople can support consumers making the switch to electric, thereby reducing the likelihood of emissions targets not being met.	This mitigation action should consider: ▪ Expansion of work that has started on initiatives to increase workforce capacity, such as the Victorian Energy Jobs Plan and the Women in Energy Strategy which are under development. (DEECA, 2024k) (Engage Victoria, 2024), and linking the workforce investment plan to other government diversity targets, including female trades, vulnerable groups, regional and remote groups, indigenous employment. ▪ Accelerating existing workforce program implementation that links to existing training programs and providers, with a collaborative approach between government, industry and workers. ▪ Ensuring sufficient trainers and educators. ▪ Providing apprenticeships. ▪ Creating loans to support re-skilling of mature age plumbers and gas fitters (beyond provision of existing free TAFE courses). ▪ Providing guidance for younger people on the career opportunities in energy (such as online career hub portals implemented in Canada that share job opportunities alongside career stories and industry events (https://www.efficiencycanada.org/career-hub/energy-efficiency-career-stories/). ▪ Locating the training centres in regional areas aligned to where the skills are needed.

Mitigation category	Mitigation action	Related risks	Purpose of/need for action	Potential benefit	Implementation considerations, including cost
					COST: High (requires cross-sector investment over a long-term period and potential development of regional facilities to support training).
Community acceptance and consumer behaviour change	Develop demand response programs to achieve higher levels of demand side participation and help balance supply and demand in Victoria in a future with more extreme demand	VH3 VH4 H1 H6 H7	Demand response is a cost-effective mechanism (ARENA, 2018) to reduce or manage peak demand, improve system reliability, reduce greenhouse gas emissions, and help to better integrate variable renewable energy resources in the system. Currently in the ISP, Victorian demand side participation capacity grows from only 266 MW in 2025 to 417 MW by 2035.	Reducing overall demand on the network addresses the reliability risk and also reduces or delays the need for network augmentation. Reduces the need for peaking generation investment and operation of existing gas peaking plant.	This mitigation action should consider: ▪ Conducting a comprehensive research and planning assessment to evaluate the role of demand response in managing extreme weather impacts cost-effectively, considering the infrequency of such events. ▪ Implementation challenges such as changing consumers' behaviours when under other pressures, for example, bushfire season. ▪ A 2017 study conducted by ARENA and AEMO to trial Demand Response in Victoria, SA and NSW was considered successful, exceeding the targeted capacity of 200MW by the end of the trial and increasing market capability in demand response delivery (ARENA, 2020). COST: Low (based on typical costs for a planning exercise).

4.2.2 Transition off coal

4.2.2.1 Key insights

The remaining brown coal generation plants need to retire by 2035 to enable achievement of the 75% to 80% emission reduction target set for 2035 (DEECA,2023b). Achievement of the 95% Renewable Energy Target (by generation) by 2035 will likely encourage retirement of these plants by then.

Risks in the timely transition away from coal are best managed through continued implementation of the VRET and CIS mechanisms, and the development of long duration storage. Successful and continued implementation of the VRET and CIS mechanisms in order to meet 2035 renewables targets would significantly contribute to achieving the end goal of removing coal from the system. In addition, the development of long duration storage is critical to providing reliable energy supply in a system with high variable renewables penetration.

Successful implementation of these two focus areas, combined with other contributing mitigation actions (e.g., improving consumer acceptance, facilitating planning approvals, providing investment certainty and developing a skilled workforce) would see only minor residual risks remain. While it is possible coal plants without an agreed exit date might stay online beyond 2035, they would likely be unprofitable, and any delay in their exit beyond 2035 is likely to be short lived, given the commercial pressures such a station would be under in a high renewables system.

Further discussion on the full set of risk mitigation actions to address the risks associated with the transition off coal are described below and provided in **Table 4-4.**

4.2.2.2 Mitigation actions

Policy and regulation. The continued implementation of the VRET through further auctions and underwriting of new capacity to support renewable generation targets in 2030 and 2035 and the Commonwealth's CIS to support the build-out of renewable developments in Victoria is critical to the transition away from coal-fired generation in Victoria. Implementation of both measures would overcome some market failures (lack of a clear signal to support low emission plant), provide clearer signals to investors of the government's intent (removing some of the uncertainty around future market developments) and would restrict the operating envelope for brown coal plant. This is a clear policy focus of both the Victorian and Australian governments, and the continued support of both schemes will help to drive the achievement of emissions reduction targets at the state level.

Long-duration storage (technologies that can store energy for extended periods, such as thermal energy storage, that can absorb and manage fluctuations in demand and supply) will be critical to the successful retirement of brown coal capacity in Victoria while maintaining standards of reliability and affordability for Victorian consumers. It is a critical mitigation measure to ensure that that brown coal capacity can exit the electricity system prior to 2035 and still maintain a reliable electricity supply.

Long duration storage development can be supported through a suite of policy options, including the provision of long-term market signals through the existing government storage target and the implementation of revenue mechanisms that support asset development, for example, through the CIS or the VRET schemes. It can also be supported through direct technology support and enabling measures such as grants, incentives and targeted tenders in Victoria.

Investment and innovation. Work should be continued on the identification of the financial requirements for the development of the preferred port to support offshore wind development.

Planning and approvals. A significant amount of planning has gone into the Victorian offshore wind strategy, and this strategy is critical to the decarbonisation of the electricity sector and the retirement of brown coal capacity in Victoria. These projects, even at a global level, are challenging and often subject to significant delays. Additional strategies to manage delays in offshore wind projects could involve developing an adaptive plan for other renewable energy options that could include determining the optimal mix of other generation assets that might fill a gap in the expected offshore wind development timing if and when it emerges.

Community acceptance and consumer behaviour change. Communicating the benefits of the transition, and in particular, the need for and benefits of major energy transition projects, is key to managing risks that centre around community acceptance of large energy transition projects. These efforts can be supported by the provision of targeted benefits to communities who are impacted by transition assets being built through their land areas, as per recent government announcements (DEECA, 2024, Victorian Transmission Investment Framework – REZ community benefits).

Demand response activities and programs will help to manage pressure on the networks and some of the costs associated with the transition. A comprehensive planning assessment should be conducted to evaluate the role of demand response in managing climate change driven extreme weather impacts (e.g., heat waves) cost effectively, considering the infrequency of such events.

Table 4-4 Mitigation of risks associated with transition from coal generation

Mitigation category	Mitigation action	Related risks	Purpose of/need for action	Potential benefit	Implementation considerations, including cost
Policy and regulation	Continue implementation of VRET and/or CIS to support the build-out of the renewable resources in Victoria (beyond 2030)	VH1 VH2 H10	To meet clean energy goals, support reliable energy supply in the course of the transition and encourage timely investment in renewable energy sources to replace reliance on thermal generation, the CIS and VRET schemes both operate through a revenue underwriting scheme, offering a guaranteed minimum income for new projects, helping to reduce investment risks. There is a need to continue and extend these schemes until the 2035 goal is met. Victoria has a renewables target for 2035 but not all capacity to reach that target is yet announced. CIS has a 2030 target, but not all capacity is yet announced and as yet there is no announcement regarding the operation of the scheme beyond 2030.	The CIS and VRET reduce the investment risks for new projects. This leads to increased investment, more timely investment and lower cost investment, ultimately reducing the costs borne by consumers, reducing emissions and supporting reliability. These schemes will help to ensure that the pace of investment in renewable capacity is sufficient to meet renewable generation goals and support the timely retirement of brown coal generators. The scheme also benefits the wider economy through job creation. Revenue underwriting schemes have also been shown to reduce the cost of capital for consumers (IEA, 2024).	▪ This mitigation action would be an extension of an existing program: VRET supports Victorian renewable energy generation targets out to 2035. Commonwealth Capacity Investment Scheme (CIS) supports build-out of variable renewable energy and dispatchable renewable resources in Victoria, as well as in other states. ▪ Ensuring that only projects that have achieved the necessary development approvals and connection agreements are awarded contracts under the auctions will in minimise the risk in targets not being achieved. The Federal Government CIS auctions have requirements that projects are at an advanced stage of development. Continued support should be considered in parallel with: ▪ Action on community acceptance to ensure the timely delivery of the infrastructure. ▪ Post-2030 market reforms. ▪ The need for additional transmission to support the mitigation action. COST: Potentially high. The cost of revenue underwriting schemes depend on wholesale

Mitigation category	Mitigation action	Related risks	Purpose of/need for action	Potential benefit	Implementation considerations, including cost
					price outcomes over the period in which these projects have revenue support. The lower wholesale prices are, the more support the government is called on to provide. The AFR in November 2023 quoted Grattan's Tony Wood as stating the exposure could be up to $1 billion "at the upper limit", but the range quoted across the industry has been wide reflecting the fact that it is driven by unknown wholesale price outcomes and will apply to 32 GW of capacity under the CIS (Greber & Ludlow, 2023).
Investment and Innovation	Accelerate investment commitment to port infrastructure	VH2	Uncertainty around the timing of port development for offshore wind industry, impacts capital commitment on a timely basis for the development of offshore wind. Offshore wind is a globally competitive market with a limited stock of construction vessels. If the necessary conditions to construct wind farms in Australia are not present, investors may allocate these elsewhere, pushing back construction timelines in Australia.	As offshore wind projects have long lead times, increased investment certainty will reduce the likelihood of project delays. With a confirmed construction port and a timeline for development of its facilities, offshore wind investors will be more willing to commit capital to begin projects in Victoria. This will support timely and efficient project progression and avoid the likelihood of project delays.	This mitigation action should consider: ▪ Budget estimates announced in the Victorian Budget 2024/25, Strategy and Outlook. ▪ Port of Hastings Victorian Renewable Energy Terminal had $27 million allocated to it in the 2023/24 budget. As of 2024 the build is estimated to cost a total of $1.4 billion. (IPA, 2024). ▪ Hastings development is subject to Commonwealth environmental approvals and discussion between the Victorian and Commonwealth governments. COST: The cost to government is medium in the short term, based on the Port of Hastings example above, however will be High in the

Mitigation category	Mitigation action	Related risks	Purpose of/need for action	Potential benefit	Implementation considerations, including cost
					longer-term including contribution to capital costs.
Planning and approvals	Develop alternatives (an adaptive plan) to manage offshore wind delay	VH2	The risk analysis identified that offshore wind delays are likely and therefore impact on meeting the emissions targets. Even with mitigation actions in place to reduce the likelihood (see above) this risk may still materialise.	This action aims to reduce the risk impact. The development of an adaptive plan will provide the foresight to enable alternative options to meet emissions reduction targets to be progressed at the right time and reduce the impact of offshore wind delays.	This mitigation action is an extension of existing efforts and could include: ▪ Creating an adaptive plan for other renewable energy options. ▪ The identification of viable alternative investment options that can be pursued as and when delays from existing stated offshore wind capacity targets can be confirmed. ▪ Determining the optimal mix of other generation types including other renewable energy sources and the timing for development of those resources should offshore wind development look like being delayed. This may also include options for extended coal use at low-capacity factors. COST: Low based on typical costs for a planning exercise.
Policy and regulation	Support the development of long duration storage. 1. Enact a suite of policy options to support the development of	H2 H5 H7	Long duration storage helps to replace retiring brown coal capacity with lower emissions alternatives, while supporting reliability. Victoria's energy storage target (DEECA, 2023b) mentions short,	Long duration storage supports the timely exit of brown coal generation and reduces emissions while maintaining affordability and reliability, particularly in a future electricity system that is required to	1. Policy options should consider: ▪ Providing long term market signals (for example – long duration storage capacity targets) to demonstrate market stability and long-term investment. (Victorian government storage target mentions "deep

Mitigation category	Mitigation action	Related risks	Purpose of/need for action	Potential benefit	Implementation considerations, including cost
	long duration storage to enter the market as coal leaves (2028-2035). 2. Develop and implement state-level plans to enhance system redundancy and ensure resource adequacy		medium and deep duration energy storage systems. However, at this stage, there are no plans yet advanced in Victoria at the individual project stage. 1. These policies are needed soon and up to and beyond 2035 in order to move specific projects forward given the long lead times involved. These proposed actions provide strong investment signals to progress long duration storage development. 2. Planning for a greater degree of redundancy in the energy system is needed to manage the impact of the exit of coal generation and more variable demand and generation patterns on the grid.	manage sustained low renewable energy periods. These actions reduce the likelihood or risk of unserved energy.	duration" storage as part of 6.3 GW by 2035 goal). ▪ Implementing revenue mechanisms that support long duration storage (cap and floor mechanisms and contracts for difference, i.e., CIS and VRET). ▪ Developing direct technology support and enabling measures (Grants and incentives, regulatory sand boxes[10], market rules, targeted tenders). COST: High. Capital costs for pumped hydro developments are high. CSIRO Gencost 2023-24 shows cost for 48 hrs storage in 2030 at around $5,900/kW. Underwriting support for such capacity is therefore likely to be high cost. 2. State-level plans to enhance system redundancy and ensure resource adequacy should consider: ▪ Coordinating state-level actions to secure adequate resources and infrastructure post coal exit (Wood, Reeve & Yan, 2024). There is a role for the Victorian Government to lead and co-ordinate stakeholders, and to

[10] A regulatory sandbox is a framework within which participants can test innovative concepts in the market under relaxed regulatory requirements at a smaller scale, on a time-limited basis and with appropriate safeguards in place. AEMC

Mitigation category	Mitigation action	Related risks	Purpose of/need for action	Potential benefit	Implementation considerations, including cost
					support long duration storage given the likelihood of the market providing insufficient investment signals for long duration storage. Planning should consider the significant lead times and the significant cost of long duration storage options. COST: High. Additional resource adequacy may involve contracts for additional capacity, at high cost.
Planning and approvals	Coordinated state planning of capacity growth and/or demand management for all 5 electricity distribution networks in Victoria.	H1	This action addresses a current planning gap as identified in Section 2.2.5. This work would address the significant changes in the use of Victorian electricity distribution networks between now and 2035 to accommodate greater rooftop PV, electrification, EVs and greater variation in demand due to climate change.	Mitigation of this risk also enables the successful, efficient and timely transition of the customers use of energy, the transition of the vehicle fleet and the transition away from fossil gas. This action would also help to identify for example the benefits of getting more embedded storage in place by 2035.	This mitigation action should consider: ▪ Assessing demand growth, evaluating extreme weather scenarios, analysing technology uptake scenarios and identifying the most cost-effective options for augmentation, management and batteries integration. ▪ How it may support other targets, electrification, EV growth, rooftop PV growth and embedded storage growth. ▪ Helping to identify lowest cost options to support growing use of the networks. This would need to be undertaken collaboratively with the distribution network service providers, while acknowledging and aligning with existing regulatory regimes (incentives) and business competition considerations between providers.

Mitigation category	Mitigation action	Related risks	Purpose of/need for action	Potential benefit	Implementation considerations, including cost
					COST: Low based on typical costs for a planning exercise, however may be higher given the scale of the assessment across all five distribution networks.
Community acceptance and consumer behaviour change Investment and innovation Planning and approvals	Improving community acceptance and supporting approvals of major energy infrastructure projects. 1. Facilitate early engagement with energy companies, local communities, councils, and landowners to address community, land use and environmental concerns, including local economic benefits, to facilitate successful and stakeholder-supported project implementation.	VH2 VH8 H10	While there are existing guidelines to support community engagement, i.e., *Community Engagement and Benefit Sharing in Renewable Energy Development in Victoria* (DEECA, 2021a), DEECA (2023h) notes that the community opposition to the Western Renewables Link project highlighted that transmission planning processes must engage communities early in the planning process to avoid delays and higher delivery costs. The Draft AEMO 2024 ISP requires the building of close to 10,000 km of new transmission lines and upgrades to existing networks by 2050. 5,000 km of this transmission delivery is in the next decade. Timely approvals will be key to	These actions are likely to increase community acceptance for projects thereby reducing the likelihood of the risk of project delays for major infrastructure projects. Actions that focus on community acceptance may also address social equity impacts of major projects, and improve community outcomes from targeted benefits, the cost of which may offset the cost of project delays. There may also be benefits to residential consumer bills. A one-year delay to transmission investment would add $12.5 billion to residential and business power bills over the long term across the NEM. (Adams, 2022)	This mitigation action is an extension of existing efforts including: ▪ Victorian Transmission Investment Framework (VTIF) reforms which are focused on better community engagement and broader community acceptance reforms in large scale infrastructure development. (DEECA, 2023h) ▪ Victorian Government announcement on 20 May 2024 introduces the draft Renewable Energy Zone (REZ) Community Benefits Plan (DEECA, 2024j) for consultation. ▪ Commonwealth 2024–25 budget introduced a reform package to realise community benefits in regional communities affected by the energy transition. (Australian Government, 2024) Extension to existing efforts should consider: ▪ Focus on continual improvement in community engagement requirements and implementation effectiveness by project developers as part of approval/regulations (e.g., consider also through third-party

Mitigation category	Mitigation action	Related risks	Purpose of/need for action	Potential benefit	Implementation considerations, including cost
	2. Provide targeted benefits (e.g., financial) to communities with transition assets being built through them 3. Review and, where possible, streamline regulatory approvals and environmental assessments for transmission projects within the next 6 months		delivering this infrastructure on schedule.	The likelihood of delay in the planning permission stage of major projects may also be reduced, thereby reducing the likelihood of these risks eventuating.	infrastructure sustainability rating schemes such as IS Rating Tool v2.1). ▪ Collaboration opportunities with energy companies and local council ▪ Good engagement processes and use of co-design practices may not guarantee success depending on the proposal and residual impacts. ▪ A related activity is to leverage and promote the success stories, where benefits have been realised and investment has been positively received such as the Silver City Energy Storage centre in Broken Hill, NSW. The project is a 200MW long duration energy storage project that contributed $240 million in economic benefits back into the local community. (Hydrostor, 2024) COST: ▪ Low cost to further develop engagement standards and processes. ▪ Medium - High cost for the provision of targeted community benefits. ▪ Low cost associated with review and update of regulatory approvals.

4.2.3 Transition off fossil gas, including electrification

4.2.3.1 Key insights

The Victorian government first released the Gas Substitution Roadmap in 2022. The Roadmap outlines how the state will use energy efficiency, electrification, renewable hydrogen and biomethane to drive down bills and cut carbon emissions in the transition away from fossil gas. This roadmap, and the suite of policy options being developed to help implement its objectives, is still in progress. The insights and recommendations developed as part of this report should be considered in the wider context of the strategic reforms and consultation that is under way as part of the implementation of the Roadmap.

Electrification of consumer gas load offers the greatest opportunity for gas demand reduction in Victoria. Risks in the transition off fossil gas in Victoria are best managed through a clear plan of action for consumer electrification and communication with the wider Victorian public on the goals, the benefits, and the role to be played by Victorian consumers. In terms of industrial uses of fossil gas, early support for the development of renewable gas projects for the industrial sector, including biomethane and hydrogen, will help to decarbonise those gas uses that cannot readily switch to electric processes, and establish momentum in the industry in order that it reach a more cost-effective scale as quickly as possible.

These two focus areas, if implemented in the near term, would significantly mitigate some of the risks and move Victoria towards the achievements of goals for the transition away from gas. The risk remains however that there are inequitable outcomes from this transition. Gas network costs are likely to increase for customers who cannot switch away from gas. Consideration will need to be given for additional measures to manage these equity impacts.

The full set of risk mitigation actions are set out below and in **Table 4-5.**

4.2.3.2 Mitigation actions

Policy and regulation. The risk of spiralling network costs, associated with gas distribution assets as overall usage of gas declines, is challenging to prevent in a future where fossil gas usage across Victoria is declining. The impacts can potentially be managed through State Government bearing the additional costs to the remaining gas consumers on particular parts of the network, and through careful planning of the declining phases in the operation of those assets. In part, it is being addressed through measures already introduced, for example, the capping of exit fees for gas consumers. However, it is a complex issue that may require greater collaboration and consultation with networks and major gas consumers and consumer representatives to resolve adequately.

Planning and approvals Electrification of Victoria's consumer gas load is critical to the emissions reduction pathway of the state by 2035, and to help the state to manage projected reductions in gas supply that are set to grow more pronounced during the current decade. The task is significant given the number of gas devices in Victorian homes at present, the required rate of transition as those devices gradually reach the end of their lives, and the varied ability of Victorian gas consumers to make decisions to move their gas appliances to electric.

The Victorian Government has commenced this process with the banning of gas connections on new homes requiring planning approvals (from 2024 onwards) and the inclusion of switching from a gas cook top to an induction cook-tops under the Victorian Energy Upgrades Program, in addition to subsidising the adoption of air source heat pump water heaters under the same program.

A carefully phased electrification transition plan to complement the programs already implemented should:

- Help to identify the required rate of conversion of each device type in each year to enable electrification of mass market gas loads according to the schedule required in the ISP. For example, a halving of residential and commercial gas demand by 2035 through electrification (as reflected in AEMO's 2024 GSOO), considering the average life of gas devices between 12 and 15 years, requires the conversion of more than two-thirds of gas devices to electric at the end of their lives.

- Help to clarify the consumer incentives in each device type on a capex and life-of-asset basis.
- Aim to clarify the barriers to conversion in all consumer segments, including for different ownership types.

Continued work on the resolution of gas supply shortfalls occurring in 2026-2028 and longer term is critical to managing reliability and affordability issues through a period of successive coal retirements. This work should consider additional supply from northern regions of Australia, gas import via LNG regasification terminals, accelerated electrification, accelerated renewable gas development, and enhanced exploration and production activity in southern gas basins. The work should consider the relative economics, timing and emissions impacts of the different solutions available to Victoria.

Investment and Innovation The development of renewable gases to help replace Victoria's current reliance on fossil gas will help to decarbonise the use of fossil gas in industrial applications and mitigate the significant risk that electrification efforts may not proceed at the pace required in the ISP. Significant work is already under way by the Victorian Government regarding renewable gases; however, there should be continued emphasis on signalling investment in renewable gases, particularly hydrogen, as an alternative for peaking gas-powered generation supply. Work should also continue on research and development in biomethane and synthetic methane, particularly in areas where Victoria has a comparative advantage (based on dominant industries/resource availability and/or environmental conditions) and there has been a gap to date in the commercialisation or scaling up of research and development.

Consumer incentives and support Consumers' uptake of new technology is critical to the transition's success. Enhancing consumer incentives for new technology and supporting them through the transition of their appliances are crucial to reducing the risks if the transition does not occur to the scale or timeframe required. For example, incentives for electrification, like buying electric appliances rather than replacement gas appliances, will be key. Even though electric appliances may have a lower lifetime cost than gas, support for consumers in making the switch is necessary. Incentives for landlords, where they are responsible for appliance investment decisions, will also have a significant impact on the adoption of electric devices across Victorian households.

Social and behavioural change Changing consumer behaviour requires communication and awareness of the changes needed and the longer-term benefits for consumers. Targeted communication campaigns on the benefits and timetable required for Victorian consumers to upgrade to all electric will be key to facilitating this part of the transition.

Supply chain management There needs to be additional support for industrial processes that rely on gas, to move away from gas to electric supply for those uses that are deemed feasible. This should incorporate research and development and financial support for businesses that have identified appropriate use cases. The development of early phase green gas supply chains should be supported for the industrial sector, including biomethane and hydrogen developments.

Table 4-5 Mitigation of risks associated with transitioning customers off fossil gas, including electrification

Mitigation category	Mitigation action	Related risks	Purpose of/need for action	Potential benefit	Implementation considerations, including cost
Planning and approvals	Initiate a planning assessment and feasibility for alternative gas supply options to resolve potential shortfalls occurring in 2026–2028 and over the longer term.	VH4	Addresses the cause of declining gas supply from Victorian and southern basin gas reserves by identifying other supply options. Helps to identify the lowest cost option within different timeframes.	This action targets the likelihood of the risk occurring. The benefit is best observed through the avoidance of high price periods similar to those experienced in June 2022. Very high gas prices, and an overall shortage of volumes available in southern markets had a material impact on wholesale electricity prices and consumer bills as a result.	This mitigation action is an extension of existing work by the Victorian Government (DEECA, 2023m), and should consider: ▪ Supply from the northern regions of Australia ▪ Gas import via LNG ▪ Accelerated electrification ▪ Accelerated renewable gases ▪ Enhanced exploration and production activity in southern basins ▪ Providing relative economics, timing considerations and emissions impacts COST: Low cost based on typical costs for a planning assessment.
Policy and regulation	Extend and budget for government bill support for consumers impacted with higher bills in predicted gas shortfall years. (2025–2030).	VH4	In periods with energy shortfalls, for example shortfalls of gas supply, consumer bills may increase in the short term. This impact may be felt in some consumers experiencing unaffordable energy costs or energy costs as a high proportion of overall household bills.	This action reduces the affordability and social equity impact of increasing gas costs.	This mitigation action should consider: ▪ The Victorian Government has programs already in place to help Victorians who need additional support with their energy bills. Consumers can seek help through the Victorian Government's Energy Assistance Program. ▪ An example of the additional assistance that could be provided through the course of the transition is the latest Australian Government budget extends relief package to provide $300 credit to every household in Australia from 1 July

Mitigation category	Mitigation action	Related risks	Purpose of/need for action	Potential benefit	Implementation considerations, including cost
					2024. The Government pool for this assistance is $3.5 billion. (Ministers Treasury Portfolio, 2024). ▪ The mitigation action should be coupled with actions on reduced consumption. ▪ Could potentially be more targeted to specific household groups experiencing energy poverty to address social equity impacts. COST: Medium - High cost depending on the ultimate design of the program e.g., means tested or broad scale consumer support.
Planning and approvals Community acceptance and consumer behaviour change Consumer incentives and support	Planning and support for consumer electrification encompassing: 1. Develop a carefully phased plan 2. Undertake a targeted communications campaign on the benefits and timetable for upgrading to all	VH5	Regarding 1), there is currently no evidence to suggest that the needed rate of conversion is happening, such as a reported annual drop in the number of connections or devices. Regarding 2), there is no evidence to suggest consumer awareness of financial metrics around electrification decisions is sufficiently high to encourage greater take up of electric devices. There is a lack of public reference sources making economic trade-offs clear for the whole life of each asset type. A communications	Clear annual targets, combined with specific incentives, will reduce the likelihood that longer-term electrification rates are not achieved. Providing consumers with information on the energy transition goals and benefits will encourage and enable consumers to make a timely switch from gas to electric. Incentives will make the electric decision more compelling for consumers	1. The planning activity should: ▪ Identify the required rate of conversion of each device type in each year to enable the electrification of mass market gas loads according to the schedule required in the ISP. ▪ Clarify consumer incentives in each device type on a capex and ongoing basis. ▪ Clarify the barriers to conversion in all consumer segments, including ownership types (e.g., renters versus homeowners). ▪ Combine with communications on energy efficiency upgrades (including insulation, appliances with high star rating). Aim for efficient electric, not simply all electric. 2. The communications program should:

Mitigation category	Mitigation action	Related risks	Purpose of/need for action	Potential benefit	Implementation considerations, including cost
	electric (electrification) 3. Consumer financial incentives for electrification, and transition away from household gas devices and incentives for landlords to electrify and move away from household devices		campaign to address consumer behaviour would support the conversion a higher share of assets needing replacement in each year. Relating to 3), electric devices typically have a higher initial cost but a lower full life cost as operational expenditures are lower. (Wood, Reeve & Suckling, 2023). Sufficient incentives are required to make the full life of asset cost benefit compelling, and to close the gap in upfront costs where this is prohibitive to many consumers.	replacing gas devices at the end of their life.	▪ Consider insights from the International Energy Agency (IEA's) advice on how awareness and behaviour campaigns can enable and motivate stakeholders and community to save energy (IEA, 2022a). ▪ Learn from effective campaigns aimed at behaviour change. An example of an impactful campaign was the Black Balloons campaign (Visualizing Climate Change, 2014). ▪ Campaign should target trades as well as the wider consumer base. 3. Development of financial incentives should consider: ▪ NSW program had positive results for solar panels. (OPSI, 2023). ▪ Incentives also need to be provided for landlords. For example, all electric appliances in minimum rental standards. The Victorian Government will improve minimum energy efficiency standards for rental properties in 2024 (DEECA, 2023k). COST: ▪ Low cost estimated for a planning activity. ▪ Low cost estimated for a targeted communications campaign. ▪ High cost for the provision of a large-scale incentives program. The Grattan report "Getting

Mitigation category	Mitigation action	Related risks	Purpose of/need for action	Potential benefit	Implementation considerations, including cost
					off gas" (Grattan Institute, 2023) identified a $400 cost gap between electric and gas cooking, $1,550 cost gap between electric heat pumps and gas, and a $1,850 cost gap between reverse cycle air con and gas ducted heating. Grattan showed an asset replacement cycle of 300-400 appliances per day for each appliance type.
Supply chain management	Support for industrial supply chains to electrify gas consumption where feasible	VH5	This action promotes research and development and financial support for Victorian businesses looking to electrify components of their supply chain that can feasibly switch from gas supply options to electrification. (Sustainability Victoria, 2024). Industrial gas consumption in Victoria in 2024 is forecast at 58.27 PJ by AEMO in the GSOO.	This action will reduce the likelihood of the risk occurring and the consequent emissions impact. At 0.5mt CO_2e per 10 PJ of gas consumption, a reduction in gas consumption represents a significant emissions reduction opportunity in Victoria.	This mitigation action should consider: ▪ The Large Energy User Electrification Support Program provides grants of $14,000 to $60,000 ex GST per project ($66,000 if regional). The program provides funding for electrification feasibility studies for businesses using 10-100 Tj per annum. Applications close in September 2024 and funding is limited. This program could be extended in funding and timing. (Sustainability Victoria (2024), Large User Electrification Program). ▪ Some industrial uses of fossil gas will not be feasible to electrify, or not be economically feasible to electrify at the current time. COST: Low cost based on the total funding of $1.58 million for the current Large Energy User Electrification Support Program (Sustainability Victoria, 2024).

Mitigation category	Mitigation action	Related risks	Purpose of/need for action	Potential benefit	Implementation considerations, including cost
Investment and Innovation	Accelerate renewable gas development pre-2030	VH6 H2 H8	In the near term the economics of renewables gases including biomethane and hydrogen are challenging as higher production costs and infrastructure development expenses can be deterrents. This action addresses the economic barriers to progressing renewable gas developments. There are currently no demonstration projects in Victoria dedicated to supplying biomethane or hydrogen to the industrial gas sector and blending in gas networks. Curtailed renewable energy, or energy that is generated but not usefully deployed in the market is a wasted resource. Curtailment can be solved through additional transmission but also through the evolution of load and where new loads are located to take advantage	This action reduces the risk likelihood and reduces the impact of lost output and economic curtailment. Early phase projects help to build up a skills base in the industry and establish the platform for commercial scale. These can utilise existing gas infrastructure while reducing emissions.	This mitigation action should consider: ▪ Work that is currently underway; for example, DEECA (2023j) released the Victorian Renewable Hydrogen Industry Development Plan and committed to releasing a directions paper in 2024. ▪ Existing projects underway include ARENA funded Lochard project (ARENA, 2024). ▪ Renewable gas targets, subsidies for renewable gas development, carbon prices on fossil fuel gases, and Guarantee of Origin (GO) schemes. ▪ Implementing policies that facilitate the integration of hydrogen and other renewable gases into the energy market. ▪ Supporting research and development to advance renewable gas technologies, for example, investment in renewable gases (such as biomethane or synthetic methane) within the next 3 years. ▪ Focusing R&D on localised and unique challenges or where there are existing strengths (Australian Industry Energy Transitions Initiative, 2023). ▪ Create partnerships with industry stakeholders to foster investment and innovation.

Mitigation category	Mitigation action	Related risks	Purpose of/need for action	Potential benefit	Implementation considerations, including cost
			of abundant renewable energy in constrained parts of the grid.		▪ Coordinate with power and gas markets to reduce coincident demand and ensure a balanced supply. ▪ Access to sustainable fuels to address hard-to-abate processes is important for the decarbonisation of the sector as a whole. ▪ Consider partnering with public water corporations and other States with shared interests and complementary inputs. ▪ Key focus would be adapting hydrogen technologies to soak up excess power at particular times of the day and incentivising their locating in areas of the grid where they could improve congestion. COST: Medium, based on expected costs of investing in partnerships, research and demonstration projects. For example, the $15 million Made in Victoria Industry R&D Infrastructure fund (Business Victoria, 2023).

4.2.4 Transition customers' use of energy

4.2.4.1 Key insights

Through their uptake of rooftop PV, Victorian consumers have played a key role in the transition of the electricity sector to date. The ability to better manage consumer's use of energy through the day, and as new load or generation is added to the system at the distribution level, becomes more important the further the transition progresses. Victorian consumers need to adopt embedded storage technology in greater numbers. Actions to encourage this and to allow for more centralised or coordinated management of these resources will help to mitigate the risk that the required rate of take up these resources falls short of what is needed in a future system with greater demand and more variable demand and generation.

Commercial and industrial businesses also have a key role to play in transitioning the use of energy in Victoria. While the potential for rooftop PV in Victoria is dominated by residential customers given the prevalence of residential roof space, commercial businesses and industry have significant potential for PV installation and associated embedded and aggregated storage. A study for the Clean Energy Finance Corporation and Property Council of Australia in 2018 (Clean Energy Finance Corporation, 2018) estimated total rooftop PV potential in Australia at 179 GW, with 9.3 GW in the commercial/business sector and 19 GW in industry and utilities. About one quarter of the overall potential for rooftop solar was seen to be in Victoria.

The full set of risk mitigation actions are described below and set out in **Table 4-6.**

4.2.4.2 Mitigation actions

Planning and approvals: Changes in both consumers use and production of energy through the transition will place additional demands on Victoria's five electricity distribution networks. For example, the electricity networks will need to provide a means for the export of increasing amounts of rooftop-generated electricity to the grid, while climate change will drive increasing demands on the network to provide electricity reliably to consumers. A coordinated state-level plan for the five distribution networks is needed to manage the significant changes in the use of these networks between now and 2035. This planning will help to meet increased demands efficiently and reliably.

Investment and innovation: Innovation, particularly in the consumer energy resources space, is critical to achieving the transition as efficiently as possible. Digitalisation allows for the better integration and use of consumer energy resources in the wider system. It means those resources can be measured, controlled and deployed far more widely than would otherwise be the case. Policies that promote digitalisation will support more flexible demand capacity, increase energy efficiency and reduce overall peak electricity load across the network. It will provide real-time digital information to consumers, energy providers and aggregators. Victoria has a competitive advantage in this space with a strong start-up and digital sector, which can be leveraged in the energy sector. The potential role digitalisation can play, particularly through collaboration between the government and the private sector, can be seen in the role of large Virtual Power Plant capacity in trials globally, for example, successful retail orchestration schemes such as Intelligent Octopus in the UK, which now offers 1 GW of capacity to the market and has described the potential to reach 18 GW by 2030. Virtual power plants are networks of small energy producing or storage devices, such as solar panels and batteries or EVs, that are pooled together or aggregated to provide electricity to the grid.

Consumer incentives and support: Incentives for embedded battery storage ownership could improve take-up rates to match the rates assumed in the ISP and to help manage broader changes in the use of energy at the distribution network level. Incentives include direct financial incentives and subsidies, and changes to network tariffs to incentivise battery installation for rooftop PV owners. Incentives for aggregated storage and other technologies that allow for centralised management of DER at times of high demand volatility will also help to both enable the transition and manage some of the challenges associated with the changing nature of the system as it moves to a higher penetration of variable renewable energy and greater levels of demand variability due to climate change.

Table 4-6 Transition customers use of energy

Mitigation category	Mitigation action	Related risks	Purpose of/need for action	Potential benefit	Implementation considerations, including cost
Consumer incentives and support	Develop options to encourage battery uptake: 1. Review of network tariff charges (in the context of current levelized battery costs) to ensure true market signals are seen by the customer to enable consumer behaviour changes including implementing battery storage 2. Increase financial incentives for battery installations such that customer payback decision comparable to that for rooftop PV systems	VH3 H1 H4	Encourages and enables more consumers to install batteries, reducing need for network augmentation.	These actions reduce the likelihood of the risks H1 and H4 occurring and also reduce the reliability impact in peak demand events (VH3). ISP projections for embedded storage in Victoria by 2035 are 3.7 GW. This is a significant amount of capacity when compared to overall Victorian peak demand (and therefore the required capacity of Victoria's distribution networks). Greater amounts of embedded storage will reduce the need for network augmentation as loads and demands on the distribution networks grow. Encourages and enables more consumers to install batteries, reducing need for network augmentation to manage new demands on the system (population growth, electrification, EVs).	This mitigation action should consider: ▪ Following the AEMC rule change in 2021 that allowed for export charges for rooftop PV, national energy market distribution networks are now introducing solar export charges. The difference between peak tariff charges and solar feed in tariffs broadly indicates the incentives for battery storage systems. This difference should be reviewed in the Victorian context and discussions commenced with Victorian networks. ▪ Network tariffs noted above incentivise batteries. These incentives should also be compared to overall costs and warrantied battery life to provide a payback period from investment. This should be incentivised, so payback is well within warrantied period of battery. ▪ Battery payback with no subsidy is closer to 9-10 years and should aim to get towards 3-5 years. ▪ Consider commercial incentives for commercial and industrial investment in battery storage systems and whether an extension of the solar for business program could target investment in battery storage systems. COST: ▪ Low for review of network tariff charges.

Mitigation category	Mitigation action	Related risks	Purpose of/need for action	Potential benefit	Implementation considerations, including cost
					▪ High for potential costs of incentives for a large number of energy consumers. Battery systems can cost in excess of $10,000 (Installed cost of Tesla Powerwall 2 $13,000-$15,000, solarchoice.com.au).
Consumer incentives and support Policy and regulation	Encourage take-up of aggregated storage and other technologies that allow for centralised management of CER/ DER at times of high volatility. Develop and implement policies to support digitalisation in the energy sector.	VH3 H1 H3	Improved demand management and management of growing DER resources in NEM, leading to improved reliability, reduced volatility, and lower grid costs. Reduces peak demand and overall demand on the electricity system. Provides for additional resources that can be supplied back to the grid flexibly and at low cost. Provide real-time digital information to consumers and energy providers. Participation in digitalisation schemes would allow for provision of data on how assets are being managed, their role in the system, and	These actions enable more optimal use of distribution networks in meeting greater energy demand from consumers and absorbing greater energy output from consumer energy resources. They also help to address the reliability impacts of more frequent extreme demand events in future. A benefit of digitalisation is in the avoided investment in alternative resources to provide the equivalent resource, as well as the better management of the system overall. This can support more flexible demand capacity and enhance energy efficiency, reducing load by optimising the use of existing appliances (AEMC, 2019)	This mitigation action should consider: ▪ The alleviation of consumer concerns around the loss of control and clarifying consumer benefits from providing another party with control of consumer owned devices. This could be incorporated into cross cutting mitigation actions relating to consumer communication/education campaigns. ▪ Encourage the use of digital building automation to optimise lighting, heating, and cooling systems and for fault detection through the use of standards, regulation and/or subsidies. ▪ The role of the action to better identify and implement control systems for CER/DER. ▪ Victoria has a competitive advantage with strong startup and digital sector which can be leveraged. For example, LaunchVic is Victoria's startup agency, established by the Victorian Government in 2016. ▪ Possible collaboration with private sector (e.g., trials for residential, commercial and industrial premises). ▪ Insights into implementation provided by successful retail orchestration schemes, such as

Mitigation category	Mitigation action	Related risks	Purpose of/need for action	Potential benefit	Implementation considerations, including cost
			their value to the system and the consumer.	Digitalisation saves both the consumer and the grid energy and money. In the UK, digitalisation has now saved around £100 million with smart metres and smart tariffs. (Octopus Energy, 2024)	Intelligent Octopus in the UK which offers 1 GW of Virtual Power Plant capacity with the potential to reach 18 GW by 2030. (Octopus Energy, 2024). COST: ▪ Low cost for development of policies. ▪ Potential medium costs associated with investment for trials, for example.

4.2.5 Transition vehicle fleet

4.2.5.1 Key insights

Risks in the timely transition of the vehicle fleet to lower emissions alternatives, and lower emissions transport in general, are best managed first and foremost through the establishment of targeted EV take up rates that allow for the growth in the overall car fleet in Victoria. Given the long-life cycle of vehicles (from initial purchase to scrapping) and therefore the elongated turnover times[11], emissions reductions opportunities in the Victorian transport fleet must be seized early for Victoria to meet its wider emissions objectives by 2035. The take up rates of EV vehicles in the private and public fleet, for light vehicles and for larger vehicles, needs to be incentivised through a range of actions across the Victorian economy and the private and public sectors.

Where the target is changed to match the growth in the vehicle fleet and the required ambition, and mechanisms are put in place to meet that target, some risk remains in terms of the wider availability of EV vehicles and EV infrastructure on the timeframe and scale required. To an extent this risk is not in Victoria's control. However, short term supply issues globally are likely to evolve as the market signals the required capacity from the industry.

The full set of risk mitigation actions are described below and set out in **Table 4-7.**

4.2.5.2 Mitigation actions

Policy and regulation Higher targets for EV sales in Victoria will help Victoria not only to meet EV penetration rates as articulated in the ISP but also to go beyond these levels by 2035, such that Victoria's overall emissions targets can be met. The current target of 50% of light vehicle sales by 2030 announced by the Victorian Government may be too low to help achieve emissions reduction goals. The draft 2024 ISP under the step change scenario sees 2.2 million BEVs and PHEVs in Victoria by 2035. As identified in **Table 3-5.** Victoria's Greenhouse gas emissions forecast to 2035 under ISP and GSOO assumptions (SEAM base case modelling outputs) the projections indicate that the emissions target may not be quite met by 2035. Based on calculations from SEAM, Victoria could aim for an additional 1-1.5 million EVs to be on the roads by 2035 in order to close that gap. While planned national changes in the form of the New Vehicle Fuel Efficiency Standard will drive EV sales at the national level, a higher sales target communicated by the Victorian Government and additional policy measures at the state level to support or complement the national scheme[12] will have a higher impact on the achievement of emissions targets.

Investment and innovation The roll out of EVs across Victoria will require investment in balanced charging infrastructure across the state for homes, workplaces and transport networks. Comprehensive support measures, including the provision of tax incentives and subsidies for the development of EV charging infrastructure, offering low interest loan schemes to providers of EV charging facilities and providing subsidies for the installation of private charging facilities in existing apartment blocks, are potential mitigation actions to reduce the risk lower consumer uptake of electric vehicles that what is needed for achievement of emissions targets by addressing perceived barriers.

Consumer incentives and support for EV ownership, and away from ICE ownership, will have a high impact on the take-up rates of EV vehicles, particularly as the new vehicle efficiency standard takes effect gradually. With the growth in Victoria's population and continued growth in the overall passenger fleet in Victoria, the decision between an ICE and an EV vehicle needs to move rapidly in favour of EVs for the majority of consumers.

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[11] For example, according BITRE (2023), the average vehicle age for passenger vehicles in Victoria is around 10.8 years.

[12] For example, lower registration fees for low emission vehicles, extending the proportion of the Government car fleet to be low emission, and extending the roll-out of charging infrastructure.

Table 4-7 Transition vehicle fleet

Mitigation category	Mitigation action	Related risks	Purpose of/need for action	Potential benefit	Implementation considerations, including cost
Policy and regulation Consumer incentives and support	Greater EV take up by 2030 1. Consider higher EV sales target, and or combined vehicle target across all segments 2. Provide consumer incentives for EV ownership and away from ICE ownership (e.g., increased tax)	VH7	1. The current stated target is 50% of small vehicle sales by 2030. This may not be enough to put 2.2 million BEVs and PHEVs on the road by 2035. To achieve 2035 emissions goals, additional vehicles beyond the ISP 2.2 million level are needed, in the order of 1-1.5 million additional BEV vehicles (refer **Section 3**) 2. Encourages and enables more consumers to switch to electric cars, thereby reducing emissions impacts from private vehicles. Additional incentives at a local level have been observed internationally to have a high impact on EV uptake, for example in Norway and in London. (Norwegian Government, 2023) (Transport for London, 2024).	These actions aim to reduce the likelihood of the risk occurring, leading to reduced emissions in road transportation across Victoria and helping to manage impact of growing vehicle fleet. Depending on the kilometres that would have been travelled in an ICE vehicle that is displaced, an additional 1m BEV could help to reduce emissions by approx. 2.2 mtCO_2e.	This mitigation action should consider: ▪ State targets, incentives or standards for freight to move to ZEVs. ▪ Effective Commonwealth mechanisms to help with EV uptake in the form of the New Vehicle Efficiency Standard. (DITRDCA, 2024). ▪ Commonwealth new vehicle fuel efficiency standard which provides an incentive on manufacturers to ensure a proportion of their sales fleet is low or zero emissions. (DITRDCA, 2024). ▪ A higher Victorian target, or broader target across different sectors, or more granular target from year to year, will help to identify where the Commonwealth measure is sufficient incentive for the desired rate of take up and whether additional measures are required at the state level in Victoria. ▪ Incentives for EV take up in other countries which involve a wide range of options, each with challenges. The UK has provided incentives such as grants and interest free loans when buying EVs, tax benefits and discounts, parking benefits and exemptions from ultra-low emission zone (ULEZ) charges. A key challenge in the UK has been the pace of charger rollout. Norway has driven very high rates of EV take up through tax exemptions, reduced road taxes, lower parking and toll fees, access to bus lanes, higher taxes

Mitigation category	Mitigation action	Related risks	Purpose of/need for action	Potential benefit	Implementation considerations, including cost
					on ICE vehicles and lower company car tax. Norway's success in EV take up led to some concerns about the tax base longer term however, and this has led Norway to begin to scale back some of these incentives. COST: ▪ Low cost for the planning exercise associated with a revised target. ▪ Medium – High for the potential cost to government of providing a range of targeted incentives and benefits.
Investment and Innovation	Implement comprehensive support measures for the development of Electric Vehicle (EV) charging facilities	VH7 H7	Addressing the risk cause of consumer concerns over range anxiety will facilitate faster uptake of EV cars. Increased charging facility locations decreases range anxiety, promoting EV purchase and usage. (Shrestha et all, 2022)	This aims to reduce the likelihood of the risk occurring by supporting timely transition of vehicle fleet and decisions at the consumer level. This may lead to a higher overall take up rate for BEVs.	This mitigation action should include: ▪ Providing subsidies and tax incentives for the installation of EV charging infrastructure. ▪ Removing applicable tariffs and barriers to facilitate easier installation and operation of EV charging stations. ▪ Offering low-interest loan schemes to providers of EV charging facilities. ▪ Providing subsidies (e.g., low interest loan scheme) for installation of private charging facilities including on street, in existing apartment blocks, etc. ▪ Developing comprehensive information and strategies to support these installations. ▪ Should be aligned with a national strategy. COST: Medium. For example, $19 million was allocated to accelerate the roll-out of electric vehicle (EV) charging infrastructure across regional Victoria

Mitigation category	Mitigation action	Related risks	Purpose of/need for action	Potential benefit	Implementation considerations, including cost
					and support the charging of EV fleets under the Zero Emissions Vehicle Subsidy Program, Solar Victoria.
Consumer incentives and support	Develop and implement tariff designs to incentivise electric vehicle (EV) charging at optimal times of the day through time-of-use pricing	H9	Without incentives EV charging profiles associated with home charging tend to reflect current electricity consumption patterns, if EV charging is not incentivised for more optimal parts of the day, this will place additional demands on distribution networks and the grid as a whole. (ARENA, 2023)	This aims to reduce the likelihood of the risk by reducing demand on the network while subsequently reducing the need for network augmentation.	This mitigation action should include: ▪ Victorian government and electricity distribution network collaboration to ensure EV roll out impact on networks is managed such that the charging profile for EVs does not result in a greater need to augment networks than is necessary. ▪ Some cross-over with tariff design to incentivise embedded storage investment and usage. COST: Low, based on potential costs associated with a planning exercise to develop tariff designs.
Investment and Innovation	Explore and implement smart charging technologies that dynamically adjust charging rates based on grid demand	H9	The purpose of this action is to reduce peak demand on the network and the wider grid and also potentially reduce charging costs for EV owners.	This action reduces peak demand on the network and the wider grid, thereby reducing the severity of reliability impacts. An outcome may also be lower emissions through lower demand for peaking gas generation than would be the case with a peakier EV charging profile. Requires less investment through the electricity system to meet the fast growing demand for	This mitigation action should include: ▪ Investigating and promoting smart charging technologies to optimise charging rates in response to real-time grid demand. ▪ Implementing demand response mechanisms to flatten peak loads and improve grid stability. ▪ Lessons learned from successful models, such as the Intelligent Octopus in the UK, which operates a 1 GW Virtual Power Plant with a forecast potential of 18 GW by 2030. ▪ Providing support and incentives for the adoption of these technologies. (Octopus Energy, 2024). COST: Medium, based on total costs of planning activity plus the provision of financial incentives to support early adoption.

Mitigation category	Mitigation action	Related risks	Purpose of/need for action	Potential benefit	Implementation considerations, including cost
				electricity to supply EVs, including peaking generation, transmission and distribution networks.	
Consumer incentives and support	Implement Infrastructure Victoria's recommendations to enhance public transport and support other modes of transport that do not use ICE vehicles	VH7	Relying only on EV take up to reduce transport emissions can place too much reliance on one technology. Supporting public transport and other modes of transport provides for a greater range of complimentary options to reduce overall transport emissions and lower severity of the risk impact overall.	This action addresses emissions and equity impacts. With more efficient, reliable, and appealing public transport, people are encouraged to mode switch, thereby reducing reliance on private vehicles with a potentially higher emissions impact per trip. This also reduces equity impacts of transport when more people have access to public transport.	This mitigation should include: ▪ Increasing service frequency and coverage, investing in major infrastructure upgrades, promoting integrated transport solutions, managing demand, improving accessibility, fostering community engagement, encouraging active transport, adopting new technologies, and supporting sustainable transport initiatives. (Infrastructure Victoria, 2021). COST: High, based on total costs including potential capital infrastructure development e.g., major infrastructure upgrades.

4.3 Summary of mitigation actions and residual risks

The identified mitigation actions, combined with ongoing Victorian Government actions, have the potential to reduce the likelihood of all the very high risks from occurring or manage consequences where that impact is hard to avoid.

Risks in the timely transition away from coal are best managed through continued implementation of the VRET and CIS mechanisms, and the development of long duration storage. Meeting the renewables target would see only minor residual risks remain. While it is possible coal plants without an agreed exit date might stay online beyond 2035 (e.g., Loy Yang B) they would likely be unprofitable. Any delay in their exit beyond 2035 is likely to be short lived, given the commercial pressures such a station would be under in a high renewables system.

Other risks remain even after the mitigation actions are implemented. Increases in coal-fired power outages, for example, are in part outside the control of the Victorian Government. With large infrastructure projects, the scale of the developments and the unique challenges involved in building these assets mean that even after implementing mitigations some level of risk of project delay will remain. Outages may occur in other regions of the NEM, and mitigating measures in other regions to deal with those outages, or lack thereof, will also impact Victoria. Measures are outlined to respond to the increasing impact of extreme weather events on reliability, however the severity and duration of these events cannot be known fully in advance.

Electrification of consumer gas load offers the greatest opportunity for gas demand reduction in Victoria. Risks in the transition off fossil gas are best managed through a clear plan of action for consumer electrification and communication with the wider Victorian public on the goals, the benefits, and the role to be played by Victorian consumers. In terms of industrial uses of fossil gas, early support for the development of renewable gas projects for the industrial sector, including biomethane and hydrogen, will help to decarbonise those gas uses that cannot readily switch to electric processes, and establish momentum in the industry in order that it reach a more cost-effective scale as quickly as possible.

The risk remains however that there are inequitable outcomes from this transition. Spiralling gas network costs for remaining gas consumers will be hard to avoid, and while these costs could be managed through bill support for vulnerable or critical customers, the risk of higher costs across a shrinking customer base remains.

As the energy transition progresses, the ability to better manage consumer's use of energy through the day, and as new load or generation is added to the system at the distribution level, becomes more important. Actions to encourage consumer adoption of embedded storage technology in greater numbers and to allow for more centralised or coordinated management of these resources will help to mitigate the risk that the required rate of take up these resources falls short of what is needed in a future system with greater demand and more variable demand and generation.

Risks in the timely transition of the vehicle fleet to lower emissions alternatives, and lower emissions transport in general, are best managed first and foremost through the establishment of targeted EV take up rates that allow for the growth in the overall car fleet in Victoria. Emissions reductions opportunities in the Victorian transport fleet must be seized early for Victoria to meet its wider emissions objectives by 2035. The take up rates of EV vehicles in the private and public fleet, for light vehicles and for larger vehicles, should be incentivised through a range of actions across the Victorian economy and the private and public sectors. Risk remains in terms of the wider availability of EV vehicles and EV infrastructure on the timeframe and scale required. To an extent this risk is not in Victoria's control. However, short term supply issues globally are likely to evolve as the market signals the required capacity from the industry.

5. Conclusion

The Victorian energy transition is complex and involves a diverse range of stakeholders, including government, agencies, industry and consumers. The electricity sector lies at the heart of Victoria's transition to a low emissions economy. Electricity is the largest emitting sector in Victoria, and it is already undergoing a process of transformation as renewable energy is built to replace the historic reliance on thermal generation (including brown coal). The electricity sector is also the key mechanism by which the next two largest emitting sectors (aside from agriculture), transport and direct combustion, can be decarbonised. However new large-scale infrastructure projects are experiencing delays, which increase the risks of access to firming capacity, creates uncertainty in integrating distributed energy resources, and increases the risk that the infrastructure pipeline falls short of being delivered.

The key research questions at the core of this project are "What are the key risks to achieving Victoria's planned energy transition up to 2030 and 2035, and what are their potential consequences?", and "What are the actions, strategies and/or measures the Victorian Government can take to mitigate or minimise these risks to achieving the energy transition"

Based on evidence obtained from reviewing energy transition plans, roadmaps, and published literature and articles, plus insights from industry professionals, stakeholder engagement, and specialised modelling, a total of forty-seven (47) risks to Victoria's energy transition have been identified with eighteen (18) of these identified as very high or high risks. These risks were assessed using a tailored risk model that considers the impacts of energy transition risks on meeting emissions targets, affordability, reliability, safety and security of supply, and social equity.

The key risks cluster around four themes, which have subsequently informed the mitigation action development:

Transition off coal. The biggest changes required in Victoria's energy system to drive the path to a low-carbon future carry the greatest number of very high and high risks. Both Loy Yang A and B will need to retire by 2035 to have any hope of achieving the 75% to 80% emission reduction target set for 2035 (DEECA, 2023b). The SEAM modelling identified changes in brown coal generation retirement dates as having the largest overall impact on the achievement of Victorian emissions objectives in 2035. There are also significant risks to the energy transition associated with the development of variable renewable energy resources (including both offshore and onshore wind), with timely delivery of major transmission projects, and with developing dispatchable resources, such as long duration storage. Delays in delivering these major projects also threaten the affordability and reliability of energy supply in the period leading up to 2035.

Transition consumers off gas. Electrification plays a significant role in Victoria's future and many of the risks associated with electrification can be linked to how decisions are made at the household or business level. The progress analysis highlighted the extent of the task that lies in front of Victoria in electrifying a large portion of its gas load before 2035, given the lifecycle of gas devices, and the required conversion rate needed to meet electrification goals. There is a very high risk that existing gas customers are not sufficiently incentivised to switch to electric alternatives, with flow on effects to the risk of spiralling gas network costs for remaining gas consumers. This has social equity consequences if groups of consumers are unable to make the switch off gas and onto electric.

Transition consumers use of energy There is a risk that households do not improve the energy efficiency of their homes as much as projected. A social equity impact of this is energy poverty which disproportionately affects vulnerable populations, including low-income households and the elderly, with those least able to invest in energy efficiency subject to higher energy costs. There is also a risk of a lack of customer take-up of embedded and aggregated storage to help manage the growing load on distribution networks in a future with greater amounts of rooftop PV and greater degrees of electrification. This would potentially mean a higher cost at the network level to integrate more electric devices and more EVs into the electricity grid.

Transition vehicle fleet There is a very high risk that consumer uptake of low- and zero-emissions vehicles is not rapid enough to achieve emissions objectives. This also has affordability and social equity implications if electric vehicles remain unaffordable for certain demographics or geographic regions.

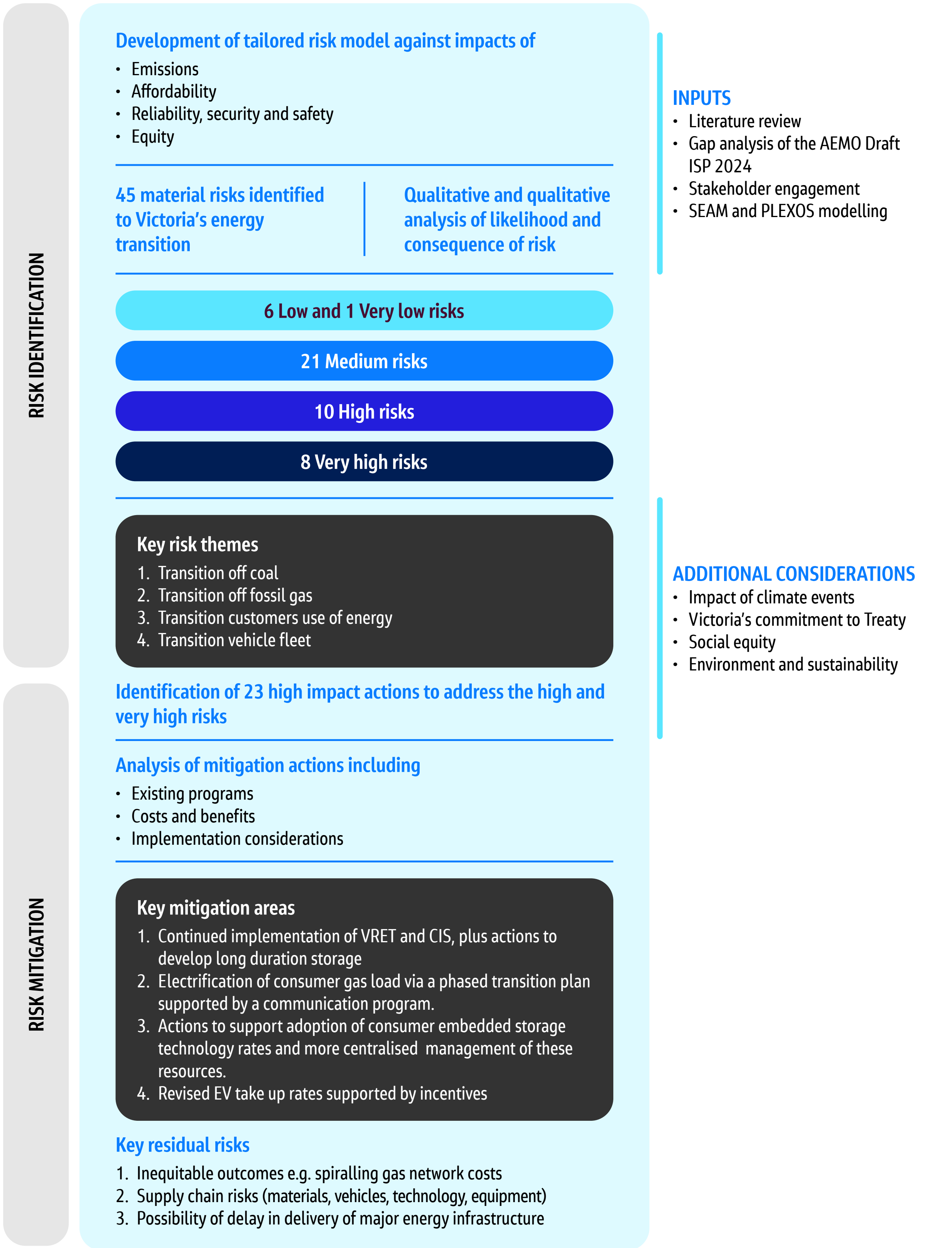

Figure 5-1 Project summary

Mitigation actions can either reduce the likelihood of a risk occurring or reduce the impacts (considering emissions, affordability, reliability, security and safety, and social equity) when it does occur. The analysis has sought to qualitatively identify the highest impact actions the Victorian government could take now to help manage the highest risks to the transition. The actions are directed at gaps in the current policies or programs, or where the challenge is so great in the timeframe that additional effort is needed now to help the state reach its ambitious goals. They cut across policy and regulation, planning and approvals, investment and innovation, consumer incentives, behaviour change, and supply chain management. The high impact mitigation actions identified cluster around the four key risk themes

- Key risks in the timely transition away from coal are best managed through continued implementation of the Victorian Renewable Energy Target Auction Scheme, through new auctions and underwriting of new capacity, and Capacity Investment Scheme mechanisms, along with the development or facilitation of long duration storage.

- Risks in the transition off fossil gas are best managed through a clear plan of action for consumer electrification and communication with the wider Victorian public on the goals, the benefits, and the role to be played by Victorian consumers.

- Actions to encourage consumer adoption of embedded storage technology in greater numbers and to allow for more centralised or coordinated management of these resources will help to mitigate the risk that these resources fall short of what is needed in a future system with greater demand and more variable demand and generation.

- Risks in the transport sector are best managed through the establishment of targeted EV take up rates, combined with incentives (to complement programs implemented by the Australian Government), that allow for the growth in the overall car fleet in Victoria noting that emissions reductions opportunities in the Victorian transport fleet must be seized early for Victoria to meet its wider emissions objectives by 2035.

- Common risk causes across major infrastructure delivery, electrification and consumer energy use are community acceptance and consumer behaviour. Continued focus and effort in community communication and education actions are therefore critical to drive support and ensure that the community understand the criticality of their participation and investment in their energy future. Effective implementation of communication protocols on relevant infrastructure projects to build community acceptance in affected communities is also vital.

- Another common risk cause is the availability of a skilled workforce to deliver major infrastructure projects and support consumers in the transition. As such, implementation of a comprehensive workforce investment plan that considers future-focused training programs, apprenticeships and finance to help re-skill the workforce for a renewable electric future is important.

Following application of the proposed mitigation measures, residual risks will remain. With large infrastructure projects, the scale of the developments and the unique challenges involved in building these assets mean that even after implementing mitigations some level of risk will remain. Measures have been outlined to respond to the increasing impact of extreme weather events on reliability, however, the severity and duration of these events cannot be known fully in advance. Risks associated with increases in coal fired power outages are in part outside the control of the Victorian government. Some risk remains in terms of the wider availability of EV vehicles and EV infrastructure on the timeframe and scale required. To an extent this risk is not in Victoria's control. However, short term supply issues globally are likely to evolve as the market signals the required capacity from the industry. The risk remains however that there are inequitable outcomes from this transition. Spiralling gas network costs for remaining gas consumers will be hard to avoid, and while these costs could be managed through bill support for vulnerable or critical customers, the risk of higher costs across a shrinking customer base remains.

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Appendix A Additional modelling information

Sectoral Emissions and Abatement Model (SEAM)

Overview

SEAM was developed by Jacobs to undertake projections of Victoria's emissions trajectory under business-as-usual conditions and under alternative scenarios, with variations around technology costs, policy prescriptions, and uptake rates. This model was used to help DEECA develop the net zero targets for Victoria.

The model is a sectoral-based model and follows National Greenhouse Gas Inventory (NGGI) sector definitions. Each sector model has drivers for production, such as Gross State Product (GSP) growth. Some sectors will relate more closely to population growth, while others may be more impacted by Gross Domestic Product (GDP) growth or commodity prices. These relationships are based on available datasets and fitting a curve to historical datasets. Elasticity factors are used to determine the responsiveness of production to a driver such as GSP or population growth. Elasticity factors are typically calculated using an 'off model'.

The model assists with the current and ongoing projections of emissions on a sectoral basis, provides insights on how emissions are tracking in comparison to the prescribed reduction targets under a range of conditions relating to economic, technological, and sociodemographic trends, and enables the modelling of any alternative policy prescriptions.

SEAM ensures:

- There is a consistent and proven approach to modelling each sector.
- Sectors are integrated to account for their connectedness.
- Interrelationships between elements of the model, both micro and macro, are captured, including accounting for the impact of one emissions abatement policy on another; and
- Business-as-usual and other scenarios were calibrated to meet the requirements and expectations of DEECA.

The diagrammatic representation of the model structure is as follows:

Assumptions

The key whole of model assumptions and constraints used for the modelling and analysis are outlined below. The assumptions listed are for the base applications. There were variations around some of the assumptions to explore the impact of the identified risks.

The assumptions are summarised as follows:

- Announced and legislated Victorian Government policies and programs are assumed to be enforced and met. Announced policies modelled include:
    - The 50% sales target for zero-emission vehicles (ZEVs) in the passenger vehicle segment by 2030 is met. Additionally assumptions under the ISP for the take up of BEV and PHEV vehicles in Victoria by 2030 and 2035 are assumed to be met.
    - Announced targets for the electrification of the public bus fleet is met.
    - Assumptions under the ISP for the electrification of gas load in Victoria by 2030 and 2035 are assumed to be met.
    - The Biodiversity 2037 target is met (200,000 ha of revegetation).
    - Waste diversion targets are met including the establishment of 1 Mtpa diversion to pre-approved waste to energy projects and target to halve organics to landfill by 2030.
    - Offshore Wind Targets are met (4 GW of offshore wind capacity by 2035 and 9 GW by 2040).
    - VRET renewable energy targets (65% of generation by 2030 and 95% by 2035) and storage targets.
    - Assumptions under the 2024 ISP for the retirement of brown coal fired in Victoria are assumed to be met.
    - Assumptions under the 2024 GSOO for the consumption of natural gas by gas fired plant in Victoria are assumed to be met.
- Socio-demographic trends for Victoria are based on Department of Transport and Planning (2023), Victoria in Future 2023, - Population and household projections to 2051.
- A social discount rate of 2% (real) and private sector discount rates varying from 5.5% to 7.0% real pre-tax.
- Primary commodity prices, which impact on activity levels in the agriculture, land use and mining sectors are sourced from price projections published by ABARES and Office of Chief Economist (Resource and Energy Quarterly, June 2023 edition). The assumption in the model is that world benchmark prices for these commodities drive production levels. Externally sourced commodity prices are typically denominated in US dollars and are converted into Australian dollars using Australian Government treasury published projections for the exchange rate.
- Energy prices are sourced externally or from the PLEXOS modelling runs (for electricity market prices), from the Gas Substitution Roadmap update and GSOO 2024 (for gas prices), and from reputable external sources in the case of coal and petroleum products (e.g., Office of Chief Economist, US Energy Information Agency).
- The shadow carbon price is based on the current price (in Dec 2023) for Australian Carbon Credit Units. For the scenario modelling, this published price is assumed to be the minimum point. The starting shadow price and the annual escalation rates were derived for each scenario as that level which achieved carbon budgets and interim emission targets.
- Total arable land area is derived from ABS estimates on land use (sourced from Agricultural Commodities and Agricultural Commodity Statistics publications). This limits the area devoted to agricultural activities after forest cover and other use areas are deducted. The allocation of arable land to broadacre activities (livestock and cropping) are based on a statistical relationship that maps land allocation to projected commodity and input prices.
- A range of physical and technical constraints are assumed including:

- The amount of biomass available for use as an energy source is limited to the amount of diverted organic waste streams, plantings of energy crops and agricultural residues.
- Technology constraints were applied to limit uptake of some abatement options (e.g. carbon anodes over the next decade) to account for projections of when they are likely to become available or to mimic technical or social constraints on their uptake. For some technologies, sigmoid uptake curves limit uptake while others have limits to annual growth in uptake applied.
- There are annual limits on the land area used for environmental plantings and agroforestry on private and public lands.
- Elasticity responses to the changes in total cost of ownership are applied in some sectors to mimic behavioural responses to adopting new technologies (this mostly applies to energy using appliances in the residential sector and affects the switching rates from gas to electric or renewable appliances).
- Hydrogen blending is assumed to only occur once the price of hydrogen falls below the price of the alternative fuel (mostly natural gas) plus the cost of switching (this only includes behind-the-meter residential hydrogen conversion costs, while additional costs such as network upgrade costs are not included) to use hydrogen. The model predicts when this breakeven point is reached 5 years out and then an annual conversion limit of 10% per annum is assumed.
- Limits are imposed on the number of energy efficient options that can be adopted in the commercial and industrial sectors. The limits are imposed to reflect that eventually the cost of an additional amount of energy efficiency would rise exponentially especially when considering the hurdles such as short payback periods and uncertainty around the future benefits of energy efficiency, with these aspects not being directly modelled in SEAM.

Modelling of abatement options

In projecting emissions from projected activity levels, SEAM allows for the potential uptake of emissions abatement options to support the activity. In the modelling, options are only taken up if they lead to a lower cost of supply for the activity. The model allows levels of uptake to be adjusted with the "optimal level" being that which minimises the present value of long-term production costs. The model uses an optimisation engine to vary levels of uptake until the minimum cost point is found.

The optimisation is done for the period 2025 to 2050 for most sectors and all abatement costs are discounted to derive present values using a user defined discount rate. A commercial discount rate is used to mimic private sector decision making around investments in abatement options.

Generally, the model:

- Allows for the full modelling of capital, operating and other costs associated with abatement options and technologies.
- Has capital cost functions for a range of abatement options, with capital cost of the options assumed to be (initially) higher than currently used alternatives. Capital costs of the options are affected by assumed technology cost declines and any subsidies available under a government program (in the model such subsidies can deduct from capital costs).
- Considers technologies that are commercially available and under development. For abatement options still under development, assumptions are made on which year the option becomes commercially available.
- Uses a sigmoid adoption curve to model uptake of passenger vehicles. Sigmoid adoption paths have an initial period of slow uptake by early movers and then a period of rapid uptake (often referred to as the flip point) before reaching saturation levels.

- Includes assumptions on the rate of technological change and the learning-by-doing impact on costs as important determinants of abatement options uptake. For immature technologies, learning-by-doing rates are adopted based on any published literature of the estimated rates.

The process of selecting abatement options is affected by interdependencies amongst the options. Examples include:

- Where uptake affects energy flows. Electrification (away from fossil fuel fired appliances or processes in direct combustion) or electric vehicle uptake reduces demand for natural gas and liquid fuels - impacting energy production emissions and fugitive emissions. This also influences the economics of abatement options in those activities (e.g., carbon capture and storage or reducing leakages in transmission). Concurrently, increasing demand for electricity because of this switch impacts on the level of low emission electricity generation needed.
- Where uptake of an abatement option might affect demand or emissions in another sector. For example, one abatement option for the waste and fugitive emission sectors is to capture methane and produce electricity, which then feeds into the energy production module and impacts on the level of low emission options taken up in those sectors. Uptake of reverse cycle air-conditioning will reduce leakage of ozone depleting substances substitutes, leading to a reduction of industrial processing emissions.
- Diversion of land use to sequestration activities may lead to reduced activities in broadacre agriculture reducing enteric fermentation emissions and reducing the need for abatement options in that sector.

More generally, within each sector, uptake of one option (due to the initial low cost of that option) may impact on the uptake of other options later in the projection period by reducing the scale of abatement required.

Table A- 1 Abatement options modelled

Energy (supply)	Energy (demand)	Transport	Agriculture	LULUCF	Industrial	Waste
Offshore wind **Onshore wind** **On-site and large scale solar** **Grid-scale batteries and energy storage** **Combined cycle gas turbine (CCGT) with carbon capture and storage (CCS)** **Biomass with CCS** **Biogas turbine** **Hydrogen reciprocating engines**	Electrification and energy efficiency Residential Commercial Industrial Hydrogen substitution Residential Commercial Industrial	Fuel switching, including electrification of transport fleet Hydrogen fuel-cell vehicles Sustainable aviation fuels	Livestock anti-methane vaccination *Feed supplements (algae and NOP) Selective breeding Crop nutrient management	Environmental plantings Establishment of hardwood and softwood plantations Agroforestry Coastal and wetland restoration and conservation (i.e. blue and teal carbon)	Replacement of carbon anode with an inert alternative CCS for selected sectors	Thermal waste to energy Improved separation of organics Recycling Anaerobic digestion and composting Additional LFG and wastewater methane capture

PLEXOS model

PLEXOS is a software platform used to model long-term, medium-term and short-term planning horizons in the electricity market. It can be used to simulate the operation of the electricity market, modelling the bidding behaviour of generators, the cost of generation, the dispatch of generation and the price of wholesale electricity over different time frames and in different regions of the market.

For any given set of government policies or government and private investment plans for generation, networks, or other infrastructure interacting with the electricity system, it can be used to forecast electricity prices, emissions, electricity flows across regions of the NEM, and reliability in terms of expected energy not served and expected hours of load shedding.

It can also be used to model a future electricity system under different assumptions on government policy, the cost of new generation technology, investment in generation and networks, and the cost of fuel for existing thermal plants, such that the impact of different policy decisions can be assessed in terms of price, emissions and reliability.

Jacobs' current PLEXOS model is updated with the latest of AEMO's ISP input assumptions, including load, wind, and solar traces, and the latest constraint workbooks to reflect constraints across the network.

Appendix B Risk Model Development

Introduction

As outlined in **Section 1** of this report, meeting the emissions reduction targets will require building new infrastructure, upgrading existing infrastructure, decommissioning other infrastructure and implementing numerous supporting programs. However, there are many potential risks associated with implementing the energy transition. For example, energy infrastructure projects are experiencing delays primarily due to slow planning approvals, grid connection challenges, community opposition, rising construction costs, labour shortages and material price increases. Supporting programs may not have the impact and reach intended.

Risks have been defined for this project as "events that, if they occur, could have an impact on Victoria's decarbonisation objectives". After identifying the risks (refer to **Section 2**), they were assessed using a risk model developed and tailored specifically for this project. The risk model used for this project articulates the risks in terms of "cause', "risk event" and "impact" (or consequence).

Cause categorisation

Risk events have a wide variety of possible causes. In many cases, a risk event will have more than one potential cause. In order to better communicate, categorise and consolidate the possible causes and also check that the coverage of risks is comprehensive, the risks have been described by sector (electricity, transport and gas) and then described by causal sub-categories, as listed below in **Table B-1**.

Table B- 1 Cause identification approach

Causal sub-categories	Definitions/Description
Consumer preferences	Relating to consumer perceptions of different options and consumer financial incentives to adopt or invest in new energy technology or services
Compliance, approvals, process	Relating to the different legal and administrative steps necessary for new developments to progress and connect with the energy system
Infrastructure	Relating to the availability of supporting infrastructure necessary for the development and delivery of energy services
Economics	Relating to the viability or economic feasibility of development options
Investment	Relating to the required rate of investment of private and public funds in order to meet development objectives in the desired timeframe
Community acceptance	Relating to community acceptance of changes or the ongoing acceptance and approval of a company or industry's operations and projects
Demand changes	Relating to the impact of changes in energy demand in future as a consequence of economic/population growth, technological changes or changes in the pattern of energy usage between sectors
Policy	Relating to the presence and performance of policies and programs that regulate the operation of the sector or support and drive the transition to a lower emissions future
Technology	Relating to the development, adoption and availability of technologies to support the transition
Environment/Sustainability	Relating to both or either: a) the potential disturbance to terrestrial and marine ecosystems; b) consideration of sustainability in the delivery of future energy assets and services

Climate change	Relating to the impact of climate change and future extreme weather events on the operation of the sector
Declining gas reserves	Relating to the decline of natural gas reserves and production capacity in Victoria and southern gas basin
Supply chain	Relating to the availability of supply chain components, services and skilled workforce to implement development objectives

Impact Categories

The impacts of risks have been categorised and scored against four areas of critical consequence for Victoria and Victorian consumers:

- Emissions
- Reliability, security and safety
- Affordability
- Social equity

Impacts have been described first in terms of the potential impact on Victoria's decarbonisation objectives.

Affordability, reliability, security and safety are as per the National Energy Objectives and capture the impacts of changes to reduce emissions on these key requirements for consumers.

The objective of providing energy for all Victorians and ensuring no Victorian is left behind is outlined in the Victorian Climate Change Strategy (2021), the SEC Strategic Plan (2023), and other key strategies, including the UN Sustainable Development Goals. This project will consider social equity through the lens of vulnerable groups and geographies who are most likely to experience a disproportionate impact of the risks associated with Victoria's energy transition.

Other impacts have also been noted in the risk assessment, though not included in the risk rating process.

International, national and state-level strategies and objectives relating to energy were reviewed to determine the important criteria in assessing the risks to achieving the planned transition. A summary of the literature review for the determination of the criteria is below.

Table B-2. References to support the impact criteria determination

Reference	Key energy objectives or statements
National Energy Objectives (1996)	The National Electricity Objective, as stated in the *National Electricity Law of the National Electricity Act 1996* (SA) is "to promote efficient investment in, and efficient operation and use of, electricity services for the long-term interests of consumers of electricity with respect to: ▪ price, quality, safety, reliability and security of supply of electricity ▪ the reliability, safety and security of the national electricity system ▪ the achievement of targets set by a participating jurisdiction — for reducing Australia's greenhouse gas emissions or ▪ that are likely to contribute to reducing Australia's greenhouse gas emissions."
Victorian Climate Change Strategy (DELWP, 2021)	"The energy sector is Victoria's biggest source of emissions. Our transition away from fossil fuels to renewable energy is reducing emissions, cutting energy costs for households and businesses, creating thousands of jobs and ensuring we have an affordable and reliable

Reference	Key energy objectives or statements
	energy system" and "Our Climate Change Strategy embraces the opportunities and addresses the challenges of change, ensuring no Victorian is left behind."
Our renewable energy future (DEECA, 2024)	"We are working to deliver a cleaner, cheaper and stronger energy system for all"
AEMO (2024) Draft 2024 ISP	The objectives of the ISP align with the National Electricity Objectives, which are to promote efficient electricity services for the long-term interests of consumers. This takes into account three sets of considerations: reliability and security, price and quality (affordability), and the need to reduce Australia's greenhouse gas emissions.
SEC (2023) Strategic Plan 2023 -2025	Working together for renewable, affordable, reliable energy for all Victorians.
Victoria's Climate Action Targets (DEECA, 2023)	This transition is reducing emissions, cutting energy costs for households and businesses, creating thousands of jobs – many in regional Victoria – and ensuring we have an affordable and reliable energy system.
Infrastructure Victoria (2022) 30-Year Strategy	A thriving future depends on reliable, affordable and sustainable energy, including efficient and productive energy infrastructure.
United Nations (2015) Sustainable Development Goal 7	Ensure access to affordable, reliable, sustainable and modern energy for all.

After review of these key documents, four key objectives for the energy sector and the future of energy supply emerge and become the basis for the assessment of risk impact for this assessment.

Criteria

One: Impact on emissions

Emissions (AEMC, National Energy Objectives), require consideration of the achievement of targets set by a participating jurisdiction:

- For reducing Australia's greenhouse gas emissions
- That are likely to contribute to reducing Australia's greenhouse gas emissions.

Victoria reported total net emissions of 80.1 Mt CO_2-e in 2021. This included 41.4 Mt from electricity generation, 18.6 Mt from transport and 18 Mt from direct combustion and fugitive emissions. Victoria has a target of net zero emissions by 2045. The impact on Victoria's emissions references the impact on the overall levels of emissions and the achievement of emissions reductions targets and net zero by 2045.

Two: Security, reliability, safety

Reliability (AEMC) requires:

- An adequate supply of capacity to meet demand (including a buffer to respond to shocks)
- A reliable transmission and distribution network.

To be reliable, the NEM must match supply with demand from consumers while keeping power system equipment within its operating requirements. The NEM must be operated over the year so that there is enough supply to ensure at least 99.998% of forecast customer demand is met each year.

Security (AEMC) requires the system to continue operating within defined technical limits even if a major element, like a generator or large consumer, disconnects from the system.

Regarding **safety**, AEMC states that there are a variety of requirements for safety under the national energy frameworks that apply to electricity, gas and related energy services.

Affordability

Affordability is defined in terms of the overall impact on consumer bills as a consequence of the risks posed by the transition. Where particular targets are not met, for example, in relation to the building of renewable generation or dispatchable power generation, this may have an observable impact on wholesale prices and consequently consumer bills. Changes in network costs and the cost of environmental schemes will also have a bearing on end-user bills.

Affordability can also be defined in terms of the number of households in energy poverty, or for whom energy bills form a large share of their overall expenses. Recent research indicates electricity accounts for 3% of household bills on average; however, it is a regressive proportion, i.e., a higher share for poorer households. Research indicates that when a household needs to spend more than 10% of their income remaining after housing costs to heat and power the home, they are in energy poverty (Simhauser 2023). Changes to overall affordability noted above will also have a bearing on the number of households experiencing energy poverty.

Social Equity

Social equity has assumed a host of different meanings but continues to centre on the principles of a fair and just treatment and the equal and equitable distribution of benefits to the society at large (McCandless, 2021; National Academy of Public Administration, 2024).

The field of social equity is broad and intersects with many other disciplines, each of which may have its own related terms and concepts. To analyse the risks associated with Victoria's energy transition we have drawn on four key terms: Social Policy, Social Exclusion, Social Equity and Energy Equity, to consider social equity impacts.

Social Policy:

"Social policy, and social equity within it, can include a variety of public contexts. This includes but is not limited to education, policing, welfare, housing and transportation. Planning for social equity means recognizing planning practices that have had a disparate impact on certain communities and actively working with affected residents to create better communities for all, so that every community member can thrive." (United Way NCA, 2020)

Social Exclusion:

"Social exclusion is a complex and multi-dimensional process. It involves the lack or denial of resources, rights, goods and services, and the inability to participate in the normal relationships and activities, available to the majority of people in a society, whether in economic, social, cultural or political arenas. It affects both the quality of life of individuals and the equity and cohesion of society as a whole" (Levitas et al, 2007).

Social Equity:

Social equity is, as defined by the National Academy of Public Administration (2024), "the fair, just and equitable management of all institutions serving the public directly or by contract; and the fair and equitable distribution of public services, and implementation of public policy; and the commitment to promote fairness, justice and equity in the formation of public policy."

Energy Equity:

Energy equity, as articulated by the Australian Energy Regulator (2022), focuses on ensuring that the energy market is inclusive for all consumers, does not create or compound harms and barriers to participation, and provides affordable energy.

As the Victorian Government embarks on the journey of transitioning to renewable energy, it's crucial to prioritise equity and ensure a just transition for all. Social equity is about taking tangible action to ensure the social and economic inclusion of all individuals, with a particular focus on underinvested communities and groups with specific vulnerabilities.

For the purpose of this project, equity has been considered through the lens of vulnerable groups and communities who are most likely to experience a disproportionate impact of the risks associated with the Victoria's energy transition.

Vulnerable groups include:

- Low-income households, and specifically low-income households in parts of Victoria which are more susceptible to climate change
- People living in public housing and rental properties
- Rural communities
- First Nations People
- Employees in the traditional fossil fuel industries, e.g., coal mining
- Communities reliant on the traditional fossil fuel industries
- Energy dependant populations, for example elderly people or people with a disability who may be reliant on heating, cooling and medical devices

Particular stakeholder groups that may be disproportionately affected by energy transition risks are considered for the risk under consideration. Scoring is based on a simple binary measure as to whether certain stakeholder groups will be impacted or not.

Scoring framework

Table details the scoring framework developed for the assessment. The scoring framework is supported by an evidence base, as summarised below.

Given the short timeframe of this project, the likelihood of the risk occurring in 2030 or 2035 and the severity of the consequences have been qualitatively scored based on the evidence, data and logical arguments obtained in the risk identification stage (refer to **Section 2**). The risks that were identified as rating very high or high were then assessed further in electricity network models SEAM and PLEXOS to provide additional, quantitative data to support the risk rating (refer to **Section 3.2** for more information on SEAM and PLEXOS).

Evidence base:

1. **Emissions**: 1% impact on emissions chosen as material or observable change. Based on Victorian emissions levels in 2021 of 81 Mt, this would represent just under 1 mtpa. Based on the required trajectory to move Victoria from the current emissions level to net zero on a straight-line basis over 22 years, just under 4 mtpa of abatement is necessary per annum. A 1% impact from any single measure could be seen to have a material or publicly observable impact on emissions or on the timeframe of achievement of the emissions objective.
2. **Safety, security and reliability**: NEM must be operated such that there is no expected breach of the reliability standard or no expected breach in future. The reliability standard requires at least 99.998% of

forecast customer demand to be met each year. Security refers to the stable operation of the NEM within technical parameters such as voltage and frequency.

3. **Affordability:** The affordability metric is a qualitative assessment of an observable change in the affordability of energy supply. A material or observable change is deemed to be $25 in a consumer's annual bill, or roughly 2–3% of the customer bill for a representative consumer in Victoria in any year. In the AEMCs 2021 residential electricity price trends report, the representative Victorian consumer is seen to use 4,727 kWh per annum. The current Victorian Market Offer would see a bill of $1,433 or 30.3 kWh. Severe changes to affordability are assessed at 10% of customer bills. This aligns with the increases experienced following the market crisis in 2022 and the impact of wholesale costs on the overall bill in the period following the market suspension and extreme wholesale price volatility.

4. **Social equity:** Within the scope of this project, the risk is flagged as either having or not having a disproportionate impact on certain groups. These groups refer to vulnerable groups and geographies that are most likely to experience a disproportionate impact of the risks associated with Victoria's energy transition. These groups have been identified in the risk statement.

Impact assessment

Table B-3. Impact assessment approach

	Minor	Major	Severe	Evidence
Emissions	No discernible impact on emissions in any one year, emissions budget to net zero, or pathway to net zero.	Material Impact on emissions, >=1% in any one year, >=1% of emissions budget to net zero. Delay in emissions trajectory of 3 months or more	Significant Impact on emissions, >=5% in any one year, >=5% of emissions budget to net zero. Delay in emissions trajectory of 1 year or more	1% chosen, as material or observable change on pathway to net zero in Victoria. Approx. 0.85 mt CO2e in 2023 or 0.4 mtCO2e in 2035.
Safety, Security and Reliability	No breach of reliability standard or very low probability.	Results in expected breach of reliability standard in any year. Reliability standard requires at least 99.998% of forecast customer demand to be met each year Security – When technical parameters such as voltage and frequency may not be maintained within defined limits Safety – potential for harm or injury	Results in expected breach of reliability standard in multiple or consecutive years. Reliability standard requires at least 99.998% of forecast customer demand to be met each year Security – When technical parameters such as voltage and frequency may not be maintained within defined limits Safety – potential for harm or injury	The reliability standard Is a measure of expected unserved energy in each region of no more than 0.002% of energy demanded in any financial year. https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/nem_esoo/2023/2023-electricity-statement-of-opportunities.pdf?la=en&hash=D8CC2D9AC8D9F353194C9DD117095FB4 Security refers to the stable operation of the NEM within technical parameters such as voltage and frequency.

Affordability	No discernible impact on end user bills in any year, price impact is below $5/MWh in wholesale market, 0.5 c/kWh on end user bills or <$25 on typical customer bill Affordability. No expected observable change in the proportion of people in energy poverty.	Observable impact on consumer bills in any year. $25 or 2–3%. Or 0.5–1.0 c/kWh on end user bills, $5–$10/MWh in wholesale market Affordability. Moderate observable change in proportion of people in energy poverty.	Significant observable impact on consumer bills in any year. $140 or 10%. Or 3 c/kWh on end user bills, $30/MWh in wholesale market Affordability. Significant change in proportion of people in energy poverty.	AEMC residential price trends and ESC VDO for current cost, typical bill. ESC VDO has residential tariffs flat rate $0.2893 first 1020 kWh, then $0.3070. Typical consumption taken from AEMC residential price trends of 4,727 kWh from 2021 price trends, expected bill $1,433 or 30.3 c/kWh https://www.aemc.gov.au/market-reviews-advice/residential-electricity-price-trends-2021 https://www.rff.org/publications/explainers/electricity-affordability-101/
Social Equity	No disproportionate impact on certain groups/stakeholders (who are, for example) unable to invest in or take up energy transition technologies (EV/Rooftop PV/Battery/Electrification)	A disproportionate impact on certain groups / stakeholders	There is a systemic and significant increase in the social, economic and health burdens for vulnerable stakeholders as the energy system transitions	The risk is flagged as either having or not having an impact that will impact certain groups disproportionally, with particular groups being identified in the risk statement.

Other impacts

Other impacts and consequences have been considered within the risk assessment process; however, they will not be used as key criteria for the risk rating process. However, once identified, these consequences will be carried forward to inform the design of risk mitigation actions.

Other consequences include, for example, reputation, jobs, lost output, environmental impact, diversion of funding and lost opportunities. Community acceptance is risk because it can lead to opposition, legal challenges, reputational damage, delays, increased costs, and, in extreme cases, project cancellations.

Likelihood assessment

Table B- 4 Likelihood assessment approach

Likelihood		
Unlikely	**Possible**	**Likely**
It is not expected to occur with a probability of less than 10%	It is possible the risk could occur in some circumstanced with a probability of 10–50%	It is expected to occur with a probability of greater than 50%

Risk assessment matrix

Each risk is then assessed by considering the consequences for emissions, affordability, reliability, security and safety, and social equity, using the scoring framework noted above combined with the anticipated likelihood of that risk occurring. This calculation provides a risk score from 'Very High' to 'Very Low'. The risks that are rated as 'Very High' or 'High' are considered the key risks and will be used as the basis for the mitigation assessment in Stage 3 of this project.

Likelihood		Impacts/Consequences		
		Minor	**Major**	**Severe**
	Likely	Medium	High	Very High
	Possible	Low	Medium	High
	Unlikely	Very Low	Low	Medium

Figure B-1. Risk rating framework

Appendix C Stakeholder Engagement

First round Stakeholder engagement

A workshop was held on the 16 April 2024 with representatives from Infrastructure Victoria, Department of Energy, Environment and Climate Action (DEECA), the Department of Transport and Planning (DTP) and Jacobs. This engagement was undertaken with the purpose of gathering insights and evidence to test and support further refinement of the risk identification and analysis.

The key insights and issues raised in the workshop which have supported the risk identification and analysis include:

- Needing to run thermal plants longer than expected (as per the ISP) is a very high rated risk and is also linked to the risk of increased coal fired power outages, which are more likely to occur the longer the plants are run
- The risk of inadequate long duration storage being available in time for coal exit is a key risk
- The risk of offshore wind developments being delayed is seen as a very high risk. The risk of not meeting the first 2 GW was noted as potentially having a more severe impact than the risk associated with the full 9 GW.
- There are multiple causes that could lead to risks of onshore VRE and clean dispatchable generation project delay or cancellation including increasing project development lead times, high costs, funding availability and the need for ongoing government support for these projects. The crucial role of enduring CIS going forward and potentially beyond 2030 was noted.
- The overall transmission build risk was viewed as very high and the cascading effect on other renewable energy projects could be severe. The government's important role in building community acceptance for these projects was noted.
- The need to build new infrastructure versus ongoing protection of biodiversity and ecological values was raised as an inherent conflict that continues to impact energy infrastructure projects and has a flow on effect to community acceptance.
- Not having an adequate workforce and availability of very specialist skills to support the infrastructure build, and the flow on effects on the planned infrastructure developments was seen as a highly rated risk.
- Risks to grid controllability were raised, however it is the view of Jacobs that this is AEMO's responsibility as system operator furthermore and is not a risk that is specific to Victoria. Any potential mitigation actions would cite steps AEMO is already cognisant of (as evidenced by the AEMO Engineering Roadmap to 100% Renewables (2022))
- The risk of existing gas customers not electrifying to the anticipated level in the ISP was seen as a very high risk, and is noted that it is inversely proportionate to the risk of spiralling gas network costs for remaining gas consumers.

Second round Stakeholder engagement

A workshop was held on 22 May 2024 with representatives from Infrastructure Victoria, the Department of Energy, Environment and Climate Action (DEECA), the Department of Transport and Planning (DTP), and Jacobs. This engagement was undertaken with the purpose of gathering insights and evidence to support the assessment of the highest impact mitigation actions and their respective implementation considerations.

The 38 actions that had been identified as those that could materially impact the risk were presented to the participants for discussion. Participants were taken through a structured workshop process to consider whether:

- The actions address a gap or are an extension of an activity that already exists or is underway

- The action is a priority for 2025–2030
- The Victorian government has a key role in implementing the mitigation action
- The proposed action can significantly address the risk by considering whether it can reduce the likelihood or impact of the risk
- Any other implementation challenges or insights.

After robust discussion, the actions that were identified at the conclusion of the workshop as having the highest impact on addressing the risks are summarised below.

Activities that address energy efficiency. Reducing (not only shifting or electrifying) energy demand was viewed as an essential mitigation action. It is viewed as potentially having a rapid impact, mitigating numerous risks for supply, storage and transmission, and buying time for implementing the other mitigation actions. Mitigation recommendations should include a focus on the role of energy consumers and energy efficiency/energy consumption.

Actions that support long-duration storage. The proposed suite of policy options to support long-duration storage was viewed as having a high impact and addressing a gap. This action should start now and will need to continue into the longer term. The government is seen to have a key role in co-ordinating stakeholders on an action that has cross-portfolio implications.

Workforce planning and training. Workforce planning and training are seen as crucial to delivering Victoria's planned energy transition and improve confidence in delivering the renewable energy infrastructure pipeline. There are a number of actions already underway, such as the Victorian Energy Jobs Plan which aims to activate underrepresented groups such as women and First Peoples, raise awareness of career opportunities, and provide regional training and opportunities.

Actions to increase community acceptance It was noted that the risk that the government and investors do not have adequate community acceptance for a range of major projects is growing and are likely to delay projects through legal challenge. As such, there is seen to be a strong need for the government to develop a comprehensive energy transition public education campaign. While a number of mitigation actions had been identified that related to community engagement and early engagement with project stakeholders, it was noted that there needs to be an overarching plan that links together all of the transition elements into a comprehensive narrative that will encourage consumer behaviour change and potentially increase support for major infrastructure projects. Elements would include linking the need for improved energy efficiency in buildings, the need to reduce demand on the overall network and why new transmission is required.

Government investment in research and development. Research and development were viewed as an essential action for the government, with suggestions including that R&D could be targeted to areas where Australia or Victoria has a comparative advantage and there is minimal spillover to other jurisdictions. Potential opportunities for R&D could go beyond investment in renewable gases and consider generation, networks and demand management. It should be focused on localised and unique challenges to get the best benefit. Implementation should go beyond research and into pilot programs and commercialisation.

Appendix D Risk Register

APPENDIX D RISK REGISTER

VERY HIGH RISKS

Low					Risk Assessment (with current controls) Severe, Major, Major, Minor or Insignificant							
					Consequences							
Risk ID	Risk Category (energy sector)	Cause	Risk Event	Risk Impacts/Consequences if the risk event occurs	Impact on Emissions	Affordability (consumer)	Social Equity	Reliability, Security and Safety	Highest	Likelihood	Risk Rating	Basis of Evaluation / Supporting Documentation
VH1	Electricity Sector	INVESTMENT: VRE Delays. Failure to meet VRE build target in the timeframe. Refer to risk event "REZ DEVELOPMENTS V1-V8 ARE DELAYED, NOT DEVELOPED TO PLANNED ISP CAPACITY" INVESTMENT: BESS and Storage delays. Failure to meet clean dispatchable power targets lead to concerns around affordability, grid stability and reliability INVESTMENT: Transmission delays. Concerns around affordability, grid stability and reliability due to lack of interconnection, or delays in major transmission projects (regulatory, supply chain) and decision making COMMUNITY ACCEPTANCE: Community concerns that renewables and storage are not able to provide reliable and affordable power through the transition from coal to renewables.	THERMAL POWER PLANTS ARE RUN LONGER THAN EXPECTED (as per ISP)	1.Emissions: Emissions targets may not be achieved 2. Security and Reliability: Reliance on ageing infrastructure could pose reliability risks (power outages) if not managed effectively 3. Affordability: In the near term, coal plant extensions may provide for lower or more stable prices. 4. Environmental Impact: An increased contribution to climate change and its associated widespread adverse impacts and related losses and damages to nature and people beyond natural climate variability. 5. Economic Impacts: Delayed retirements in order to maintain lower energy prices may impact investment decisions in renewable energy infrastructure. It may also require more maintenance expenditure longer term or have economic impacts through lower reliability, such as the cost to the economy of power outages, as plants age. 6. Public Perception and community acceptance: If deferrals are perceived as favouring vested interests over public welfare or environmental goals, it could erode trust in energy policies and decision-makers.	Severe	Minor	Minor	Minor	Severe	Likely	Very High	Victoria has to accelerate development of renewable energy, distributed PV and onshore wind in mid term and offshore wind and industrial wind in the long term to reach ODP under the draft ISP 2024. Policies to achieve this are Renewable Energy Target Scheme and Commonwealth Capacity Investment Scheme (CIS). Announced retirement dates (or expected dates based on current announcements) are currently well after the dates modelled: Victoria, Government of. (2023, August 23). Agreement Secures Transition for Loy Yang A. Premier of Victoria Energy Australia (2021). Energy Australia power ahead with energy transition Australian Energy Market Operator (AEMO). (2024). Generation information. Generating unit expected closure year file - February 2024 IPCC AR6 WGII Summary for policy makers
VH2	Electricity Sector	INVESTMENT: Offshore wind projects require substantial capital investment, even with Government auction process, the high capital outlay and long/complex planning processes required may deter potential investors or delay development. ECONOMICS: High Capital costs, and changes in capital cost projections may result in project delays TECHNOLOGY: The marine environment off the coast of Victoria can pose challenges. Factors such as strong currents, wave heights, and seabed conditions affect the feasibility and safety of offshore wind installations. Complex engineering designs are necessary for offshore wind turbines, foundations, and transmission infrastructure. Technical challenges related to installation, maintenance, and grid integration can lead to delays or cost overruns. CLIMATE CHANGE: Extreme weather events can damage equipment, delay construction or impact operational efficiency SUPPLY CHAIN: Availability of skilled labour, specialized vessels, and equipment for offshore construction is critical. Delays in procuring components or logistical challenges can affect project timelines and costs. SUPPLY CHAIN: Questions around suitable ports being identified to support offshore wind developments COMMUNITY ACCEPTANCE: Public perception, community consultations, and stakeholder engagement play a significant role. Opposition from local communities or concerns about visual impact, noise, and fishing activities can hinder project progress. ENVIRONMENT/SUSTAINABILITY: Potential impacts on the marine environment or biodiversity hinder or delay project approvals	OFFSHORE WIND TARGETS NOT MET	1. Emissions: Delays might result in a prolonged reliance on coal-based energy sources, hindering the transition to renewable energy targets set by the government. 2. Reliability and Security: Delays or reductions in offshore wind capacity would see less energy available in the Victorian energy system and less diversity in the supply sources available. While wind is not a firm source of energy, it diversifies sources of energy in Victoria.	Severe	Major	Minor	Minor	Severe	Likely	Very High	CSIRO reports the anticipated capital costs for offshore wind installations in 2028 are estimated to be $5356 per kilowatt of installed capacity, nearly three times higher than the corresponding cost for onshore wind, which stands at $1915 per kilowatt. (CSIRO, 2023) AEMOS's Draft ISP states that significant reductions in costs would be needed for offshore wind to feature in the energy mix. (Australian Energy Market Operator, 2024) Rising inflation, supply chain disruption from turbine manufacturing requirements, high interest rates and lengthy waiting times for permits and grid connections all contribute to increased timelines and budgets for offshore wind projects. Over $30 billion in investment has been deferred due to delays in at least 10 offshore wind projects across the United States and Europe. Swedish company Vattenfall estimate costs of building offshore wind farms have increased 40% in 2023. (Financial Review, 2022) The winds of change: using marine spatial planning to create a responsible, nature-positive offshore wind industry. vnpa.org.au/publications/winds-of-change
VH3	Electricity Sector	CLIMATE CHANGE: Increase in number of extreme heat events. DEMAND CHANGE: Population growth will also see overall load increase and constraints on local distribution networks, further increasing the impact of extreme demand events	MORE FREQUENT EXTREME CLIMATE WEATHER EVENTS INCREASE FREQUENCY AND UNPREDICTABILITY OF PEAK DEMAND EVENTS	1. Emissions: Higher peak electricity demand may mean increased thermal generation (coal, natural gas), leading to higher emissions. 2. Security and Reliability: 1 in 20 or 1 in 50 year events now occur more often, requiring greater generation and network investment. During extreme heatwaves, the strain on the electricity grid can lead to supply shortages. Insufficient supply may result in rolling blackouts or localised power outages, affecting homes, businesses, and critical infrastructure. 3. Security and Reliability: The electricity grid faces increased stress during peak demand periods, potentially leading to equipment failures or reduced reliability. Transformers, substations, and distribution lines may be impacted by extreme heat, affecting overall system performance. 3. Social Equity: Vulnerable communities may struggle to afford air conditioning or cope with extreme heat. Disparities in access to cooling resources can widen during heatwaves.	Minor	Major	Minor	Severe	Severe	Likely	Very High	The number of very hot days (>40 °C) will increase from 0.83 to 2.7 days per year in Melbourne, and from 7.8 to 17 days per year in Mildura. The CSIRO reports that there has been an increase in the frequency of months that are hotter than usual. In the period from 1960 to 1989, monthly maximum temperatures that were considered very high occurred approximately 2% of the time. However, in the more recent period from 2007 to 2021, these same very high temperatures now occur over 11% of the time. This significant increase highlights the impact of climate change on temperature extremes. (CSIRO, 2022)
VH4	Gas Sector	DECLINING GAS RESERVES: Rapid decline in Victorian and southern gas basin production capacity and reserves. GSOO identifies peak supply issues on extreme demand days from 2025, seasonal supply gaps under high winter demand from 2026 and 2027 and annual supply gaps from 2028. DEMAND CHANGES: GSOO forecasts annual GPG consumption to increase from the early 2030s, with significant growth in peak day consumption. POLICY: Commonwealth price caps (through the mandatory Code of Conduct) discourage investment in new supply and regas terminal economics. Government released new acreage for offshore gas exploration in 2018 and 2020. There is a ban on unconventional gas production onshore. COMMUNITY ACCEPTANCE: Opposition in Victoria to offshore drilling.	PEAK AND ANNUAL GAS SUPPLY SHORTFALLS	1. Emissions: The gas sector plays a crucial role in Victoria's energy transition. Any disruptions due to gas shortages could hinder progress toward this goal, including through delays to coal retirements 2. Affordability: More peak price events with scarcity pricing. 3. Security and Reliability: Physical shortfalls of gas, particularly where winter peaking gas system demand coincides with high electricity demand and unplanned outages to coal plants. Increased likelihood of outages of gas plants as there is less redundancy in the gas system as supply declines. 4. Equity: Potential for certain groups to be disproportionally impact if they have not been in a position to electrify their residence	Minor	Severe	Minor	Severe	Severe	Likely	Very High	AEMO 2024 GSOO shows risk of shortfalls on some days in winter in Southern Australia under extreme peak conditions. From 2026 and 2027, potential for seasonal supply gaps, from 2028, forecast annual supply gaps as southern production declines. (Australian Energy Market Operator, 2024)
VH5	Gas Sector	ECONOMICS: The transition to electric appliances and systems can be costly for consumers. This includes the upfront costs of purchasing new electric appliances and the potential costs of upgrading electrical systems in homes. COMMUNITY ACCEPTANCE: While electrification can lead to long-term savings on energy bills, these savings may not be immediately apparent to consumers. The perceived lack of immediate financial benefit can deter consumers from making the switch. COMMUNITY ACCEPTANCE: Consumers may not switch to electric if they are not aware of all the benefits of electrification, including environmental benefits POLICY: Policy such as the Victorian Government's Energy Upgrades scheme may not offer rebates sufficient to encourage and maintain assumed rate of electrification	EXISTING GAS CUSTOMERS DON'T ELECTRIFY TO THE ANTICIPATED LEVEL PER THE ISP	1. Emissions: A reduced pace of electrification than planned could impact Victoria's ability to meet its climate goals and reduce greenhouse gas emissions. 2. Affordability: Consumers who don't electrify may miss out on savings through lower energy bills 3. Affordability: Continued use of gas appliances means continued dependency on fossil fuels. This not only has environmental implications but also leaves consumers exposed to fluctuations in international gas prices. As gas reserves decline, dependency on gas imports from northern regions or regas terminals may grow. 4. Equity: Potential for certain groups to be disproportionally impacted	Severe	Major	Major	Minor	Severe	Likely	Very High	There is a significant cost to fully electrify existing households and they will not change without a government incentive. Some households and small businesses prefer gas and will not transition quickly The Victorian Energy Upgrades program has expanded to offer incentives of up to $3,600 to install a wider range of efficient electric appliances such as heat pumps and reverse cycle air conditioners, while previous incentives for gas appliances have been phased out. Incumbent industry, such as gas networks (AGIG), continue to push for gas use to support viability of their assets longer term. Plumbers may push residential homes to stay with gas in order to protect their businesses. Electric appliances are often more expensive to purchase than gas alternatives, even with government incentives, this inconvenience and cost associated would dissuade many homes from switching, prolonging the timeline to zero gas reliant homes.(Grattan Institute, 2023) With 5 million households in Australia relying on gas, and Victoria being the most reliant state, 200 households a day would need be fully phased out of the network to reach the goal of zero reliant homes by 2050. (Grattan Institute, 2023)
VH6	Gas Sector	ECONOMICS: The economics of renewables gases including biomethane and hydrogen are challenging, at least in the near term. Higher production costs and infrastructure development expenses can be deterrents. INFRASTRUCTURE: Building the necessary infrastructure for renewable gas production, storage, and distribution is capital-intensive. Existing natural gas infrastructure is not always compatible with renewable gas INVESTMENT: Investors seek stable regulatory environments. Policy gaps create uncertainty, affecting investment decisions. Capital flow into renewable gas projects may be limited. TECHNOLOGY: Developing efficient and cost-effective methods for producing renewable gas (such as electrolysis for hydrogen or anaerobic digestion for biomethane) is an ongoing challenge. TECHNOLOGY: Investment in renewable gas R&D may decline COMMUNITY ACCEPTANCE: Lack of awareness about renewable gas and its benefits can lead to limited public support and political will. Public perception may not fully recognise the potential of renewable gas as a clean energy solution. POLICY: A lack of policy backing may lead to scepticism and resistance. ENVIRONMENT/SUSTAINABILITY: Perception of development and use of renewable gases such as hydrogen and biomethane as 'greenwashing'	LACK OF RENEWABLE GAS DEVELOPMENTS	1. Emissions: Missed opportunities in decarbonisation making it more challenging to meet the emissions targets. 2. Energy Security and Reliability: Missed opportunity to diversify energy sources and thereby improve security and reliability 3. Technology: Breakthroughs in technology and efficiency could be delayed leading to delays in renewable gas availability	Severe	Major	Major	Major	Severe	Likely	Very High	2024 GSOO shows reduction in natural gas demand if uncertain hydrogen and biomethane is developed. Shows 30 PJ by 2035, and 15 PJ by 2030. (Australian Energy Market Operator, 2024) VGPR 2024, table 22, shows a summary of primary barriers to increased production of renewable gas, and its use. Includes lack of a unified approach, lack of carbon abatement recognition, lack of targets, financial risks of market entry. (Australian Energy Market Operator, 2023, Table 22) Australian Energy Market Operator (AEMO). (2024). 2024 Gas Statement of Opportunities https://www.abc.net.au/news/2024-04-23/gas-industry-sponsoring-masterchef-australia-hydrogen-biomethane/103753000

Low					Risk Assessment (with current controls) Severe, Major, Major, Minor or Insignificant							
					Consequences							
Risk ID	Risk Category (energy sector)	Cause	Risk Event	Risk Impacts/Consequences if the risk event occurs	Impact on Emissions	Affordability (consumer)	Social Equity	Reliability, Security and Safety	Highest	Likelihood	Risk Rating	Basis of Evaluation / Supporting Documentation
VH7	Transport sector	INFRASTRUCTURE: The availability of charging stations significantly impacts electric vehicle adoption. If charging infrastructure is scarce or inconveniently located, potential buyers may hesitate to switch. If there are too few charging points, potential EV owners may hesitate due to concerns about running out of power during their journeys. i.e. Range anxiety COMMUNITY ACCEPTANCE: Industries and businesses may not see sufficient benefits in transitioning to electric vehicles due to operational challenges or perceived risks. Recharging time requirements makes BEV solutions for double shifted trucks unacceptable. INVESTMENT: Establishing a robust charging network requires substantial investment. If the costs are not adequately addressed, it can hinder the expansion of charging stations, making EV adoption less attractive. POLICY: Policy incentives may be insufficient to support sales targets underpinning assumptions in the ISP COMMUNITY ACCEPTANCE: Insufficient communication and outreach about available incentives can hinder uptake. ECONOMICS: Even with incentives, the upfront cost of BEVs and FCEVs can be higher than traditional internal combustion engine vehicles. Consumers may perceive this as a barrier. Resale value versus Internal Combustion Engine (ICE) vehicles will also be a factor. ECONOMICS: Growing vehicle fleet in Victoria means new ICE vehicles will continue to be added even while BEV and PHEV sales increase.	CONSUMERS UPTAKE OF BATTERY ELECTRIC VEHICLES (BEV) AND PLUG-IN HYBRID ELECTRIC VEHICLES (PHEV) NOT HIGH ENOUGH TO ACHIEVE EMISSIONS OBJECTIVES	1. Emissions: Consumer uptake delay could hinder Victoria's progress toward achieving its decarbonisation goals. The transportation sector is a significant contributor to emissions, and without widespread electric vehicle adoption, the state may fall short of its commitments. 2. Affordability: Lost opportunity for households to save on fuel costs. Savings can be approx. $1,800-2,000 per annum depending on kms and overall petrol prices. 3. Security: Lost opportunity to increase resilience in the transport sector as continued reliance on ICE vehicles poses energy security risks as production of fossil fuel declines. 4. Social Equity: Inequitable Access to Clean Transportation: Without effective incentives, electric vehicles may remain unaffordable for certain demographics or regions. This exacerbates social and economic disparities as these groups may be disproportionately represented amongst those reliant on ICE vehicles 5. Economic Disadvantages: Delayed electric vehicle adoption can have economic repercussions. The automotive industry, charging infrastructure providers, and related businesses may miss out on growth opportunities leading to reduced job creation, missed economic benefits, and potential loss of competitiveness.	Severe	Major	Minor	Minor	Severe	Likely	Very High	To achieve net zero emissions, and the commitments in the Victorian emission reduction pledges, Victoria must adopt alternative transport technologies, like zero emissions electric and hydrogen vehicles. Includes consideration of relative cost of the new vehicle, and also depreciated or resale value. The adoption of zero-emissions vehicles in Australia is significantly lagging other countries with less than 4% of new cars being electric compared to 9% globally. In Victoria, only 6.6% of new light vehicles sold are EVs. (D'Ambrosio, 2023) Latest sales figures from the FCAI show EV sales have increased in March as a proportion of overall sales, to 9.5% in March 2024. Federal Chamber of Automotive Industries (2024). New Record for March New Vehicle Sales New Vehicle Efficiency Standard, will place a requirement on manufacturers to reduce emissions from new passenger vehicles by more than 60 per cent by 2030, and roughly halve emissions of new light commercial vehicles over the same period. The announcement also refers to $60m under the driving the nation fund to boost EV charging at Australian dealerships. Department of Infrastructure, Transport, Regional Development, Communications and the Arts. (2024). New Vehicle Efficiency Standard Introduced In 2023, the Victorian Government walked back their EV incentive program prematurely, decreasing consumer incentive to switch to EVs. Without a consistent attractive incentive, the switching cost of for lower-income households may be greater than simply retaining their petrol vehicle, leading to undershooting BEV and FCEV adaption targets. (Akhtar, 2023) There has been a 22% increase in fast and ultra-fast charger locations in Australia since 2021. Approximately 350-450 chargers are now available to the public. However, this growth rate may not be keeping pace with the surge in EV sales, which are estimated to have increased by 65% since 2021. The availability and convenience of charging stations significantly influence electric vehicle adoption, as insufficient infrastructure or inconveniently located chargers may deter potential buyers and contribute to range anxiety. (Electric Vehicle Council, n.d.)
VH8	Electricity Sector	ECONOMICS: Projects require significant funding commitments. Funding constraints could arise from budget limitations, changes in government priorities, or economic downturns. Competing infrastructure projects or shifting priorities may lead to projects being deprioritised. 8 REZ developments across a +20 year timeframe may see cost increases against current projections. COMPLIANCE, APPROVALS, PROCESS: ISP shows rapid scale up in capacity from 2028 to 2040, particularly around development of offshore wind. High risk of project delays for major infrastructure projects on this scale. COMPLIANCE, APPROVALS, PROCESS: Regulatory approvals and compliance play a crucial role in infrastructure projects. Delays or rejections due to environmental concerns, land acquisition issues, or legal disputes could hinder the project or increase costs. TECHNOLOGY: Complex engineering and technical challenges may arise during project execution. COMMUNITY ACCEPTANCE: Public opposition, community protests, or disagreements among stakeholders (such as local residents, environmental groups, or indigenous communities) could lead to project delays or abandonment. SUPPLY CHAIN: Disputes with contractors, delays in procurement, or contractual disagreements could affect project implementation. ENVIRONMENT/ SUSTAINABILITY: Potential environmental impact of infrastructure on the local environment hinders project approvals and construction	MAJOR TRANSMISSION PROJECT DELAYS (MARINUS LINK, VNI WEST, V1-V8 REZS, WESTERN VIC, EASTERN VIC)	1. Emissions: Delays could postpone the reduction of greenhouse gas emissions and hinder progress toward climate goals, given its impact on the development of onshore and offshore VRE in Victoria. 2. Emissions: Delayed implementation of any single project might have a bearing on retirement of brown coal through period. 3. Affordability: Delays may impact electricity prices, supply-demand balance, and market competition. If it is delayed, it could affect market participants, energy trading, and investment decisions. 4. Reliability: Increased interconnection supports security and reliability with a greater diversity of supply sources. Delays to interconnection will impact overall reliability.	Severe	Major	Insignificant	Major	Severe	Likely	Very High	AEMO, 2023 Electricity Statement of Opportunities, (August 2023) states delays to any projects have the potential to result in periods of high risk (of delays and disruptions) throughout the 10-year horizon An average Victorian residential consumer will pay more than an additional $1,500 in energy bills over 15 years due to a two-year delay in critical transmission projects, with a four-year delay resulting in an increase of approximately $4,800. (DEECA 2023h) https://www.abc.net.au/news/2023-07-04/federal-government-launches-transmission-line-review/102559232 highlights deepening grassroots opposition to several big-ticket power lines required for the transition towards renewable energy.

HIGH RISKS

Low Risk ID	Risk Category (energy sector)	Cause	Risk Event	Risk Impacts/Consequences if the risk event occurs	Risk Assessment (with current controls) Severe, Major, Major, Minor or Insignificant Consequences Impact on Emissions	Affordability (consumer)	Social Equity	Reliability, Security and Safety	Highest	Likelihood	Risk Rating	Basis of Evaluation / Supporting Documentation
H1	Electricity Sector	DEMAND CHANGES: Growing demand for electricity due to factors including population growth, increased urbanisation, and economic development. INFRASTRUCTURE: Geographical differences: Investment and capacity development is not always equal across geographic areas. TECHNOLOGY: Rapid Technological Changes: The rise of rooftop photovoltaic (PV) systems, electric vehicles (EVs), and electrification loads (such as heat pumps) will significantly impact electricity demand and the need to accommodate rooftop PV.	INADEQUATE MANAGEMENT OF ADDITIONAL LOADS AND FLOWS ON DISTRIBUTION NETWORK	1. Emissions: Slower growth in rooftop PV and electrification due to network limitations will impact emissions 2. Affordability: Some networks may not allow for required growth in rooftop PV, EVs and electrification on the ISP planned timescale, these are all measures that act to reduce consumer bills. 3. Security and reliability: Voltage Instability: Insufficient network capacity can lead to voltage fluctuations and instability. When the distribution network is unable to handle the load from rooftop photovoltaic (PV) systems, electric vehicles (EVs), and electrification loads, it can result in overloaded transformers, substations, and power lines. Overloading can cause equipment failures and blackouts. 4. Safety: Overloaded infrastructure poses safety risks. For example, overheated transformers or power lines can lead to fires or electrical accidents. 5. Social Equity or regional impacts. Regional disparities may grow as some network areas will have more spare capacity to allow for rooftop PV growth and increasing load, than others.	Major	Major	Major	Major	Major	Likely	High	The AEMO's ESOO projects that the total electricity consumption in the NEM is forecast to increase significantly to account for electrification, EVs, rooftop PV, economic growth.. From the current level of approximately 195 terawatt-hours (TWh), the consumption is expected to surpass 420 TWh by the year 2049-50. Residential Consumption: Specifically, residential electricity consumption is projected to grow substantially. By 2050, residential consumption alone is estimated to reach 150 TWh. (AEMO, 2024) (AEMO, 2023, p. 3) The Solar Homes program is a 10-year initiative in Victoria designed to empower more than 770,000 households. It achieves this by providing rebates for solar photovoltaic (PV) systems, solar batteries, and solar hot water installations. Since its launch in August 2018, over 110,000 Victorians have accessed the Solar Homes program. Solar PV export constraints: Before applying for a Solar Homes PV rebate, eligible Victorians must ensure that their retailer has obtained pre-approval from the Distributed Network Service Provider (DNSP) to connect their solar system to the grid. Distribution businesses sometimes impose export limits on solar systems to maintain network voltages and manage reliability risks. As a result of insufficient capacity of distribution networks, the number of beneficiaries from these programs will be limited leading to undershooting AEMO targets. (Solar Victoria, 2020)
H2	Electricity Sector	DEMAND CHANGES: Low Minimum Demand: declining minimum operational demand influenced by factors such as rooftop solar generation. The level of minimum electricity demand is lower than anticipated, which affects the grid's capacity to accommodate offshore wind and other Variable Renewable Energy (VRE) resources. TECHNOLOGY: Offshore wind introduces a large source of renewable energy that may not be easy to accommodate during these minimum demand periods. This may lead to economic curtailment of VRE	CURTAILMENT OF VRE RESOURCES DUE TO LOW MINIMUM DEMAND LEVELS.	1. Emissions: Lost VRE output may mean higher overall emissions intensity of the NEM than would be the case if minimum demand periods could be managed and VRE not curtailed during low demand periods. 2. Affordability: Low demand periods lead to Economic curtailment and lost output from VRE impacting consumer bills.	Major	Major	Major	Major	Major	Likely	High	Growth of rooftop PV and projected low levels of minimum demand presents huge problems for AEMO. Requires quicker ramp up for generators, creating a risk of unit failures, also presents risk of unsecure operating state and risk of blackouts. Victoria will see growth in PV but also large amount of offshore wind generation capacity. Australian Energy Council (AEC). (2021). Is minimum demand causing a major headache
H3	Electricity Sector	POLICY: Historical Lack of Energy Efficiency Standards: Insulation standards were introduced in 1991 in Victoria and minimum energy efficiency requirements for new houses were introduced in 2003 through the Building Code of Australia . Many existing homes lack proper insulation and energy-efficient features. POLICY: Primary program supporting energy efficiency measures in Victoria is the VEU. Question of whether this program and changes under review in this program, such as the inclusion of insulation in the program, are sufficient to deliver the required reductions in energy consumption and the reductions in peak energy consumption. ECONOMICS: Upgrading energy efficiency of a home involves an upfront cost that can be a barrier for some. Additionally, some households cannot make physical changes to their home due to rental restrictions. Landlords may not invest in energy efficiency as they may not receive the benefits from the investment	HOUSEHOLDS DO NOT IMPROVE ENERGY EFFICIENCY OF THEIR HOMES AS MUCH AS PROJECTED.	1. Emissions: Less than expected energy efficiency uptake could increase emissions, or lead to missed opportunity to avoid emissions 2. Affordability: Increased Energy Costs for Households who do not implement energy efficiency measures. 3. Security and Reliability: Inefficient energy use, particularly during peak periods, places strain on energy infrastructure, including power grids and distribution networks. This can lead to reduced reliability, and increased maintenance costs. 4. Equity: Energy poverty disproportionately affects vulnerable populations, including low-income households, the elderly, and people with disabilities. Inadequate policies perpetuate social inequities, as those who can least afford high energy costs bear the brunt of inefficiencies. 5. Health and Well-Being Impacts: Inadequate energy efficiency can directly affect residents' health and well-being. Poor insulation, inadequate heating, or lack of cooling can lead to uncomfortable living conditions. Cold homes can contribute to respiratory illnesses, exacerbate existing health conditions, and impact mental health.	Major	Major	Major	Major	Major	Likely	High	CSIRO data on the NatHERS star rating distribution indicates that 65.4% of Class 1 dwellings in Victoria are 2 stars or below – this equates to a stock of 1,367,766 sub-standard homes. https://www.sustainability.vic.gov.au/research-data-and-insights/research/research-reports/the-victorian-healthy-homes-program-research-findings The VEU program is expected to deliver around 78.5 million tonnes of greenhouse gas emissions savings since it began in 2009. (Essential Services Commission, 2023) Under the sensitivity analysis, the total renewable energy share would be only 63% by 2030, less than the 82% target, and NEM emissions would overshoot their 2029-30 emissions targets by approximately 155Mt CO2-e 33 . (Australian Energy Market Operator, 2024) The Gas Substitution Roadmap reports over 2 million Victorians currently use gas in their homes and businesses, making it crucial to address its environmental impact. The Victorian gas sector contributes approximately 17% of the state's net greenhouse gas emissions. Households may hesitate to adopt energy efficiency measures due to initial costs associated with transitioning from gas to electric appliances. These costs include purchasing new equipment, installation, and potential modifications to existing infrastructure. (Department of Energy, Environment and Climate Action, 2024)
H4	Electricity Sector	CONSUMER PREFERENCES: Consumer incentive for battery installation is not yet as compelling as solar PV. COMMUNITY ACCEPTANCE: Growing commentary in the press on the risk of fires with distributed batteries. COMMUNITY ACCEPTANCE: Hesitance on part of consumers to provide permission to government of institutions to control their DER (Distributed Energy Resources) systems, above and beyond that required by law.	LACK OF CUSTOMER TAKE UP OF EMBEDDED AND AGGREGATED STORAGE.	1. Emissions: Rooftop PV penetration is slowed down by technical limitations at network level leading to reduction or delay in low emissions consumer resources deployed. 2. Security and Reliability: Distribution networks will require greater levels of augmentation the lower the level of storage at the distributed level, to meet rooftop PV and max demand requirements. 3. Security and Reliability: Inadequate energy storage deployment can result in grid instability during peak demand periods. Without sufficient storage capacity, managing fluctuations in energy supply becomes challenging. 4. Security and Reliability: Aggregated storage may allow for more centralised control and visibility on distributed resources. Lower take up would see less visibility, less predictable and controllable power system.	Major	Major	Minor	Major	Major	Likely	High	CER quarterly carbon market report shows 8% of new installations have a battery installed as well. AEMC report on incentives for batteries in 2023 shows incentives for battery investment still finely balanced for Tesla batteries, but incentives are dependent on future tariff structures. Clean Energy Regulator. (2023). Quarterly Carbon Market Report: December Quarter 2023. https://cer.gov.au/markets/reports-and-data/quarterly-carbon-market-reports Australian Energy Market Commission (AEMC). (2023). Turning point for incentives to invest in residential batteries. https://www.aemc.gov.au/turning-point-incentives-invest-residential-batteries
H5	Electricity Sector	TECHNOLOGY: As coal generators age, they may not be as well maintained given operators plans to close stations and the high cost of refurbishment. Evidenced by recent coal station reliability issues. ECONOMICS: Economics of refurbishment may be challenging with end of asset life in sight.	INCREASE IN COAL FIRED POWER OUTAGES	1. Affordability: Energy Shortages: As aging coal-fired generators experience more frequent breakdowns and extended maintenance periods, there is a higher risk of energy shortages and prolonged extreme high prices. 2. Affordability: Increased Reliance on Gas and Imports: When coal generators are out of service, the grid relies more heavily on gas-fired power stations and electricity imports from neighbouring states. This increased reliance on gas can strain the gas supply network and impact energy prices. 3. Reliability: Frequent breakdowns and prolonged maintenance periods impact the overall reliability of the electricity grid. Sudden outages can lead to voltage fluctuations, affecting sensitive equipment and causing disruptions.	Minor	Major	Minor	Severe	Severe	Possible	High	Callide C failure in 2022 illustrates the risks. AEMO has made assessment of the impact of ageing coal assets on reliability. Australian Energy Market Operator (AEMO). (2020). Assessment of ageing coal fired generation reliability AEP Elical. https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/inputs-assumptions-methodologies/2020/aep-elical-assessment-of-ageing-coal-fired-generation-reliability.pdf?la=en
H6	Electricity Sector	CLIMATE CHANGE: Climate change is significantly increasing the risk of bushfires in Victoria. The fire season has lengthened, now spanning from October to March, due to hotter days and more frequent heatwaves. Drought conditions have intensified in Australia's southeast, exacerbating fire risk. These changes in climate contribute to an increase in dangerous fire weather, leading to more frequent and severe bushfires. CLIMATE CHANGE: Heatwaves, wildfires, cyclones, and floods, pose a significant challenge to electricity systems. These extreme events are a significant cause of large-scale outages. Noting recent large scale outages in Victoria.	EXTENSION OF FIRE SEASON REDUCES GENERATION AND TRANSMISSION RELIABILITY, EXTREME WEATHER IMPACTS TRANSMISSION RELIABILITY	1. Security and reliability: Extended fire seasons pose a significant threat to the power grid, transmission and generation, infrastructure. The network infrastructure (including transformers, switchgear, and distribution lines) is at risk. Substation fires can disrupt electricity flow, affecting multiple areas simultaneously. 2. Security and reliability: Collapsed power lines, damaged substations, and tower collapses may require extensive repairs. Repairing and restoring the network can be time-consuming and costly. 3. Economic Impact: Extended power outages can lead to financial losses for businesses. Manufacturing, retail, and other sectors may suffer due to production halts or reduced operations. Loss of revenue, increased operational costs, and damage to equipment can strain the economy. 4. Health and Safety Risks: Hospitals, emergency services, and medical facilities rely on uninterrupted power. Outages can jeopardize patient care, medical equipment, and life-saving procedures.	Major	Major	Minor	Severe	Severe	Possible	High	Victoria can expect longer fire seasons, with around 40% more very high fire danger days (Climate Change in Australia, n.d.). In 13 Feb 2024 a storm in Victoria led to 135,000 Victorians without power. State energy minister called for national approach to weatherproof the electricity grid. Severe weather led to the collapse of six 500 kV towers on the Moorabool to Sydenham lines. this tripped Loy Yang A. (Guardian) Climate Change in Australia. (n.d.). Victoria - Climate Change in Australia. https://www.climatechangeinaustralia.gov.au/en/changing-climate/state-climate-statements/victoria/ Guardian (2024). Thousands of Victorian remain without electricity as inquiry launched into mass power outages. https://www.theguardian.com/australia-news/2024/feb/20/victoria-power-outages-electricity-latest-news-updates-restoration-inquiry-launched
H7	Electricity Sector	TECHNOLOGY: Retirement of thermal generation: The retirement of thermal generation leads to a lack of ability to provide firming generation. TECHNOLOGY: During Dunkelflaute, there is a lack of both solar and wind energy production. This can happen due to prolonged overcast conditions or calm weather, resulting in reduced electricity output from renewable sources. TECHNOLOGY: While batteries are useful for managing daily fluctuations, they are not well-suited for longer durations. Most batteries have less than four hours of storage capacity. DECLINING GAS RESERVES: Gas Shortfalls: GSOO shows seasonal shortfall in gas supply from 2026 and annual shortfalls from 2028	INADEQUATE LONG DURATION STORAGE IN TIME FOR COAL EXIT	1. Emissions: Relying on non-renewable firming options (like gas peaker plants) during Dunkelflaute can have environmental consequences. It may increase greenhouse gas emissions, offsetting the benefits of renewable energy. 2. Security and Reliability: Dunkelflaute poses reliability challenges for the market. The market must find alternative sources of power to meet demand during these periods. If not managed effectively, it can lead to blackouts or load shedding in extreme scenarios and prolonged periods of very high prices in others. 3. Affordability: Increased Costs: To address Dunkelflaute, additional firming technologies are needed to supply the grid at low capacity factors. These technologies (such as batteries, pumped hydro, or gas peaking or hydrogen capable gas peaking plants) come with high cost to provide long duration energy storage. To the extent solutions are not fully developed, this may lead to extended periods of high prices during winter where the system as a whole is short of energy.	Major	Major	Minor	Major	Major	likely	High	GSOO 2024 shows seasonal shortfall in gas supply from 2026, driven by declining supply in southern basins, and increasing demand for gas for GPG Australian Energy Market Operator (AEMO). (2024). 2024 Gas Statement of Opportunities
H8	Gas Sector	DEMAND CHANGES: As consumers shift toward cleaner energy sources, the demand for natural gas may decrease. Gas assets built for a larger customer base could become underutilised, impacting their financial viability. ECONOMICS: High operational and maintenance costs, which may increase as assets age.	SPIRALING GAS NETWORK COSTS FOR REMAINING GAS CONSUMERS.	Affordability: Gas consumers remaining on the network pay more for gas network services as gas asset owners seek to recoup cost of assets Social Equity: Consumers and gas users who are unable to switch away from gas pay a disproportionate burden for the continued maintenance and operation of the asset.	Minor	Major	Major	Insignificant	Major	Likely	High	The AER has identified how the decline in gas demand can have several impacts. First, reduced gas connections mean fewer customers to share fixed costs, potentially leading to increased prices. Second, the burden of unpaid past investments may shift to future gas customers. Third, there's a risk of economic stranding for gas networks. Finally, price volatility and uncertainty could further reduce demand, exacerbating the unequal distribution of cost burdens. (Australian Energy Regulator, 2023) The Australian Energy Regulator (AER) has decided to narrow the price gap between temporary and permanent gas disconnection services by setting a charge of $220 for the disconnecting consumer, with the remaining costs of the permanent gas disconnection service being recovered through the networks' haulage tariffs spread across all gas consumers.(Department of Energy, Environment and Climate Action, 2024) (Energy Networks Australia, 2021) ECA commissioned report on the risks to gas consumers of declining demand. Energy Consumers Australia (2022). Risks to gas consumers of declining demand (Boardroom energy)

Low					Risk Assessment (with current controls) Severe, Major, Major, Minor or Insignificant							
					Consequences							
Risk ID	Risk Category (energy sector)	Cause	Risk Event	Risk Impacts/Consequences if the risk event occurs	Impact on Emissions	Affordability (consumer)	Social Equity	Reliability, Security and Safety	Highest	Likelihood	Risk Rating	Basis of Evaluation / Supporting Documentation
H9	Transport sector	CONSUMER INCENTIVES: Natural EV charging profile on a flat tariff likely to favour existing peaks, therefore adding significant load, and increased peaking requirement. INFRASTRUCTURE: Increase in peak usage profile due to EVs will require network augmentation and management solutions. INFRASTRUCTURE: Availability of public charging infrastructure and the variety of options (home, office, highway, car parks, etc) may impact profiles. TECHNOLOGY: Battery Sizes and Charging Speeds: EVs with larger batteries tend to require more energy during charging. As battery capacities increase, the charging profile may become peakier. Ultra-fast chargers, while convenient for long trips, can contribute to peak demand due to their high charging speeds. COMMUNITY ACCEPTANCE: Behavioural Barriers and Preferences: Factors such as perceived charger scarcity, queuing, and inconvenient locations can influence charging behaviour.	EV CHARGING PROFILE IS PEAKIER THAN ANTICIPATED IN THE ISP	1. Reliability: Energy Grid Strain: A peakier charging profile can strain the energy grid during specific hours. High demand concentrated in short time spans may lead to overloading of local transformers and substations. Grid operators may need to invest in infrastructure upgrades to accommodate the increased load, which can be costly and time-consuming. 2. Reliability: Increased Peak Demand Charges: Commercial and industrial EV charging stations often face peak demand charges based on their highest usage during specific time intervals. A peakier profile can result in higher electricity costs. Businesses and public charging providers may need to manage their charging schedules strategically to minimise peak demand charges. 3. Environmental Impact: If EVs predominantly charge during peak hours, while thermal stations still provide a firming role, this will draw more on these stations, increasing gas fired generation emissions. 4. Policy and Planning Challenges: Challenges for policymakers in providing the right incentives for consumers to charge outside peak periods 5. Social Equity: Peakier profiles may disproportionately affect certain communities or regions.	Insignificant	Insignificant	Insignificant	Severe	Severe	Possible	High	The AGL EV orchestration trial looks at different modes for orchestrating and controlling customer charging patterns, it shows control is highly effective at managing peak loads. In this report and in other presentations they have shown that a completely unconstrained charging profile does tend to peak when the rest of electricity consumption peaks. The ISP assumes a particular load profile over time. Actual load profiles may turn out to be peakier than the one assumed by AEMO in the ISP depending on control of customer charging and incentives to charge at different times of the day. https://arena.gov.au/assets/2022/09/agl-ev-orchestration-trial-lessons-learnt-report-4.pdf
H10	Electricity Sector	INVESTMENT: Availability of private finance in Victoria to back projects ECONOMICS: Changes in Capital costs. For example wind costs have significantly increased in recent years SUPPLY CHAIN: Workforce availability in Victoria seen as a major constraint. SUPPLY CHAIN: Access to key supply chain components SUPPLY CHAIN: Access to land. COMPLIANCE AND APPROVALS: Increasing development lead times may delay timely build out. POLICY: Lack of clear policy post 2030 may impact build beyond that date, for example CIS scheme target 2030 capacity COMMUNITY ACCEPTANCE: Public perception, community consultations, and stakeholder engagement play a significant role. Opposition from local communities or concerns about visual impact, noise, and fishing activities can hinder project progress. ENVIRONMENT/ SUSTAINABILITY: Potential environmental impact of infrastructure on the local environment hinders project approvals and construction	DEVELOPMENT AND FUNDING RISK FOR ONSHORE VARIABLE RENEWABLE ENERGY (VRE) AND CLEAN DISPATCHABLE RESOURCES	1. Emissions: Delays or scale back in development of onshore VRE and dispatchable power will likely push back coal retirement dates, impacting emissions objectives. 2. Reliability, Security and Safety: Delays in development of clean dispatchable power and other new firming technology will have a bearing on ability to retire coal while maintaining reliability 3. Affordability: Lower VRE build will men less zero short run marginal cost energy in the system. Less clean dispatchable power will impact pricing in peak periods. 4. Social Equity: Increase in the cost of wholesale electricity may be borne disproportionately by vulnerable groups	Major	Insignificant	Insignificant	Major	Major	Likely	High	The CEC provides regular reporting on progress to meet renewable targets. https://assets.cleanenergycouncil.org.au/documents/resources/reports/clean-energy-australia/Clean-Energy-Australia-2024.pdf The CEO notes in the 2024 report that 2023 saw a slowdown in new financial commitments to utility scale generation capacity at $1.5billion, significantly down on $6.5 billion for 2022. This reflects a more complex and challenging landscape for new investment decisions, which continue to include a constrained grid, slow planning and environmental assessment processes in some jurisdictions, higher costs and tighter markets for equipment and labour. The policy environment has also been uncertain, with a long-term Renewable Energy Target which is scheduled to wind-up at the end of 2030.

MEDIUM RISKS

Risk ID	Risk Category (energy sector)	Cause	Risk Event	Risk Impacts/Consequences if the risk event occurs	Risk Assessment (with current controls) Severe, Major, Minor or Insignificant — Consequences: Impact on Emissions	Affordability (consumer)	Social Equity	Reliability, Security and Safety	Highest	Likelihood	Risk Rating	Basis of Evaluation / Supporting Documentation
M1	Direct Combustion	POLICY: Lack of programs to decarbonise this sector ECONOMICS: Feasibility of alternative fuel options may be challenging	Primary industries liquid fuel emissions not reduced	1.Emissions: Risk impact is low given level of abatement assumed in this category	Major	Minor	Minor	Minor	Major	Possible	Medium	SEAM model. Commonwealth state and territory greenhouse gas inventories. https://www.dcceew.gov.au/climate-change/publications/national-greenhouse-accounts-2020/state-and-territory-greenhouse-gas-inventories-data-tables-and-methodology National Greenhouse and Energy reporting scheme data. https://www.dcceew.gov.au/climate-change/emissions-reporting/national-greenhouse-energy-reporting-scheme#:~:text=The%20National%20Greenhouse%20and%20Energy,energy%20production
M2	Direct Combustion	POLICY: Lack of programs to decarbonise this sector ECONOMICS: Feasibility of alternative fuel options may be challenging	Construction industry liquid fuel emissions not reduced	1.Emissions: Risk impact is low given level of abatement assumed in this category	Major	Minor	Minor	Minor	Major	Possible	Medium	SEAM model. Commonwealth state and territory greenhouse gas inventories. https://www.dcceew.gov.au/climate-change/publications/national-greenhouse-accounts-2020/state-and-territory-greenhouse-gas-inventories-data-tables-and-methodology National Greenhouse and Energy reporting scheme data. https://www.dcceew.gov.au/climate-change/emissions-reporting/national-greenhouse-energy-reporting-scheme
M3	Electricity Sector	INFRASTRUCTURE: Network limitations may be main driver of reduced uptake. Also lacklustre take up of embedded storage	Rooftop PV capacity added lower than projected in ISP	1. Emissions, Rooftop PV supplies renewable energy to consumers. Lower level of rooftop PV, may mean higher usage of thermal generation, higher emissions 2. Security and reliability: Rooftop PV reduces some peak evening load. Less energy in the system, means energy supply must be sourced from elsewhere	Major	Major	Major	Major	Major	Possible	Medium	Australian Energy Market Operator (AEMO). (2024). Draft 2024 Integrated System Plan (ISP).
M4	Electricity Sector	ECONOMICS: Insufficient incentives, or incentives not clear to energy users COMMUNITY ACCEPTANCE: Lack of awareness of benefits to customer and grid of offering DSP. TECHNOLOGY: May not be the technology available to allow end users to offer DSP or more DSP into the grid INVESTMENT: Demand response may require investment in some instances in order for a consumer to derive benefit from offering the service CONSUMER PREFERENCES: Incentives may not support demand response in many instances	Demand side participation not as great as projected in ISP	1.Emissions: More firming and peaking generation required. Greater emissions as a result. Emissions: Emissions are higher in some scenarios (3mt in NERA study) Consumer NPV $6-18bn, emissions 0-3mt 2. Security and reliability. DSP is a key source of firming power particularly when extreme demand events occur 2. Affordability: Inframarginal rent is higher during peak pricing periods (NERA study). DSP has also been found to be one the cheapest sources of firming power available.	Major	Major	Minor	Major	Major	Possible	Medium	Australian Energy Market Operator (AEMO). (2024). Draft 2024 Integrated System Plan (ISP). ARENA completed a study in April 2022 "Load flexibility Study". https://arena.gov.au/assets/2022/02/load-flexibility-study-technical-summary.pdf
M5	Electricity Sector	CLIMATE CHANGE: Reduced inflows to hydro schemes due to climate change More frequent and extended droughts	Reduced hydro availability due to flow reduction due to climate change	1. Emissions. Low hydro year would see need for energy to be replaced, most likely by gas, with a consequent emissions impact 2. Security and Reliability: Impact on security and reliability, particularly for longer duration events, dark lull 3. Affordability: Risk of very high price or volatile years in NEM impacting consumer bills	Minor	Major	Major	Major	Major	Possible	Medium	AEMO 2024 ISP. AEMO in its draft 2024 ISP Inputs and Assumptions workbook has an assumption "Hydro Climate Factor". This inflow adjustment is applied as a scalar to the historic al reference years. In VIC in the step change scenario this is -3-4% in 2025-2027, increasing over time. Actual impacts to hydro inflows may be greater or less than this figure.
M6	Electricity Sector	ECONOMICS: Potential for increasing in build costs in Victoria and Victorian regions. Noting slowdown in wind approvals in 2023 through high cost of wind build currently.	Increasing cost slows development of renewables	1. Emissions: Reduced or slowed VRE and dispatchable power build could potentially see delay in coal retirements	Major	Major	Major	Minor	Major	Possible	Medium	Australian Energy Market Operator (AEMO) 2023 Electricity Statement of Opportunities (August 2023) observed that the initial target delivery dates provided by developers of new generation and storage investments often have not accounted for delays that could occur during the project financing, planning, development and delivery stages of projects
M7	Electricity Sector	COMPLIANCE, APPROVALS, PROCESS: Increasing complexity in legal and administrative steps required for new developments to progress and connect with the energy system ECONOMICS: Increases in costs, or inflation, in the wider economy may lead to increased connection costs	Generator connection cost increases	1. Emissions: Reduced or slowed VRE and dispatchable power build would likely see delay in exit of coal, and increase in emissions 2. Affordability: Reduced VRE and dispatchable power build out may lead to tighter supply demand balance over the longer term. 3. Security and reliability: Reduced dispatchable power build may lead to concerns about availability of firming power in peak periods.	Major	Major	Major	Minor	Major	Possible	Medium	The connections reform initiative was created by the CEC and AEMO effectively to deal with the challenges of connection in the NEM, the complexity, cost and timeframe of the process. It recommended a number of rule changes which are being implemented. The existence of the initiative demonstrates the degree of industry concern around the costs and timeframe of the connections process. https://www.cleanenergycouncil.org.au/advocacy-initiatives/energy-transformation/connections-reform-initiative
M8	Electricity Sector	COMPLIANCE, APPROVALS, PROCESS: Increasing complexity in legal and administrative steps required for new developments to progress and connect with the energy system ENVIRONMENT/SUSTAINABILITY: Continued or increased environmental concerns delay project approvals	Increasing project development lead times	1. Emissions: Reduced or slowed VRE and dispatchable power build would likely see delay in exit of coal, and increase in emissions 2. Affordability: Reduced VRE and dispatchable power build out may lead to tighter supply demand balance over the longer term. 3. Security and reliability: Reduced dispatchable power build may lead to concerns about availability of firming power in peak periods.	Major	Minor	Minor	Minor	Major	Possible	Medium	Australian Energy Market Operator (AEMO) 2023 Electricity Statement of Opportunities (August 2023) observed that the initial target delivery dates provided by developers of new generation and storage investments often have not accounted for delays that could occur during the project financing, planning, development and delivery stages of projects
M9	Electricity Sector	ECONOMICS: Fuel prices are linked to international markets. Through export of coal and gas. High international prices tend to be reflected in high cost of firming generation in Australia.	High fuel price/affordability for consumers	1. Affordability: High prices and reliability impacts in peak periods	Insignificant	Major	Minor	Major	Major	Possible	Medium	High gas prices in 2022 (along with high coal prices) drove very high electricity prices in the NEM. The volatility seen in the ACCC LNG netback shows the degree to which prices can change, given their international linkages. While the forward curve is relatively stable over the next 2 years, historic prices have significant volatility, and this can be expected to impact the cost of gas in the NEM and therefore electricity prices. https://www.accc.gov.au/inquiries-and-consultations/gas-inquiry-2017-30/lng-netback-price-series
M10	Electricity Sector	INVESTMENT: Policies are in place through CIS and Victorian Storage target to build clean dispatchable power. However, costs are high and require significant private investment	Shallow, medium and deep storage projects delayed	1. Emissions: Thermal coal and gas continue to manage variability of supply. Storage technologies support the early exit of coal 2. Security and reliability: All storages support a more reliable grid. 3. Affordability: Greater degree of shallow and deep storage provides for more competition in the provision of peaking power, reducing prices.	Major	Minor	Minor	Major	Major	Possible	Medium	AEMO 2023 Electricity Statement of Opportunities confirm the urgent need for investment in generation, long-duration storage and transmission to achieve reliability requirements over the next decade
M11	Electricity Sector	ECONOMICS: CCS is currently expensive, energy intensive and unproven when deployed at large scale	Carbon Capture Storage (CCS) technology failure in delivering abatement at commercial cost	1. Emissions: Higher emissions particularly in relation to fugitives from gas production	Major	Minor	Minor	Minor	Major	Possible	Medium	Cost of CCS has been identified as the major challenge preventing the widespread adoption of this technology An assessment of CCS costs, barriers and potential. Energy Strategy. November 2018. https://www.sciencedirect.com/science/article/pii/S2211467X18300634?via%3Dihub#sec3
M12	Electricity Sector	SUPPLY CHAIN: Lack of available and skilled workers . Workforce shortages for key industries under transition and supporting transition	Skilled workforce not available for Renewable Energy project development and operation	1. Emissions: Delay in RE projects and delay in transition	Major	Minor	Minor	Minor	Major	Possible	Medium	Australian Industry energy transitions imitative. Skilling Australian industry for the energy transition (https://energytransitionsinitiative.org/). 194,000 workers will require training in new skills specific to the renewable energy industry across solar, wind hydrogen and storage https://arena.gov.au/assets/2023/02/skilling-australian-industry-for-the-energy-transition-accenture-report-for-australian-industry-eti-phase-3.pdf
M13	Electricity Sector	COMMUNITY ACCEPTANCE: Effectiveness of First Nations stakeholder engagement programs. TECHNOLOGY: Lack of awareness about new technology may hinder take up rates amongst First Nations communities. INVESTMENT: Ensure sufficient investment, programs and resources to support achievement of the objectives of the Strategy	First Nations Clean Energy Strategy not implemented to degree anticipated	1. Emissions: Lost opportunities in the clean energy transition. Lower community acceptance in VRE build, lower technology take up. 2. Social Equity: First nations communities may not experience the benefits available from a faster transition. Many First Nations communities currently experience unreliable and expensive power	Major	Minor	Major	Insignificant	Major	Possible	Medium	First nations support for and participation in clean energy transformation, as partners, is a key priority under the National Energy Transformation Partnership. Development of the First Nations Clean Energy Strategy is underway (as at April 2024) and will include ensuring First Nations self-determining rights, perspectives, views and decision-making are integrated into energy and climate change policy-making and program development. https://www.energy.gov.au/energy-and-climate-change-ministerial-council/working-groups/first-nations-engagement-working-group/first-nations-clean-energy-strategy Department of Premier and Cabinet, First Peoples State Relations, Treaty for Victoria, https://content.vic.gov.au/sites/default/files/2022-12/Treaty-for-Victoria-.pdf
M14	Electricity Sector	INVESTMENT: Periods of low prices, or volatile price periods where prices are low can send a low market signal to investors and potentially delay investment. Challenging to develop projects based on market economics alone, given extent of government support offered under state schemes and the CIS	Investor uncertainty due to market price signals	1. Emissions. Lower VRE build out, delay in coal exit, higher emissions. 2. Affordability: Reduction in investment in RE projects, tighter supply demand balance and higher prices longer term	Major	Minor	Minor	Minor	Major	Possible	Medium	Internal assessment. Volatile wholesale prices, without support mechanisms, have a bearing on the cost of capital paid by investors.
M15	Electricity Sector	ECONOMICS: Landlords may have lower incentives for electrification, in that they bear the cost, but the renter receives the benefit	Low incentives for landlords to transition properties away from fossil gas	1. Emissions: Reductions from residential electrification are not met 2. Social Equity: Inequity amongst owner-occupiers and renters	Major	Major	Minor	Minor	Major	Possible	Medium	Grattan Institute (2023) Getting off Gas: Why, How and Who should pay. https://grattan.edu.au/report/getting-off-gas/
M16	Gas Sector	POLICY: Programs by Victorian Government are focused on the residential sector. DEECA predominantly targets the mass market at the household level. Not much attention is drawn to businesses and industries.	Electrification in business and industry slow	1. Emissions: Emissions reductions from electrification are not met 2. Security and reliability: Electrification helps to reduce gas demand and peaking gas demand, this supports security and reliability, hence lower levels of electrification may see more issues with security and reliability	Major	Minor	Minor	Minor	Major	Possible	Medium	AEMO GSOO projects electrification in residential and commercial sector and industrial sector. Residential and commercial electrification far outweighs assumptions for industrial. However, still presents a risk, particularly in the commercial space (versus the projection of electrification assumed by AEMO in the ISP). AEMO's 2024 GSOO continues to forecast risks of gas adequacy gaps in southern states from 2028, as production in the south continues to decline faster than demand.
M17	Gas Sector	COMMUNITY ACCEPTANCE: Gas sector shrinks as electrification progresses	Gas workforce is displaced and there are job losses in the sector	1. Social Equity: Inequitable outcomes in communities that rely on gas extraction and processing for employment.	Insignificant	Insignificant	Major	Insignificant	Major	Possible	Medium	Australian Industry energy transitions imitative. Skilling Australian industry for the energy transition (https://energytransitionsinitiative.org/). Slide 35, 5,100 workers engaged in the gas supply industry. 18,7000 in oil and gas extraction 91,500 carbon workers in total https://arena.gov.au/assets/2023/02/skilling-australian-industry-for-the-energy-transition-accenture-report-for-australian-industry-eti-phase-3.pdf

Risk ID	Risk Category (energy sector)	Cause	Risk Event	Risk Impacts/Consequences if the risk event occurs	Risk Assessment (with current controls) Severe, Major, Major, Minor or Insignificant							
					Consequences							
					Impact on Emissions	Affordability (consumer)	Social Equity	Reliability, Security and Safety	Highest	Likelihood	Risk Rating	Basis of Evaluation / Supporting Documentation
M18	Gas Sector	DEMAND CHANGES: With electrification, and continuing use of gas for power, the overall capacity factor of gas usage, and therefore peakiness of usage should increase. This means fixed costs for pipelines, and storage are paid by low gas volumes, which means costs per unit of energy delivered increases.	Pattern of gas usage gets peakier, increasing costs	1. Affordability 2. Social equity	Minor	Major	Minor	Major	Major	Possible	Medium	Risks of gas shortfalls are forecast from 2025 on some days under extreme winter conditions for southern states if high heating demand coincides with high demand for gas-powered electricity generation. Retirements in coal generation, affecting the utilisation of gas-powered electricity generation (GPG) as the electricity system incorporates higher levels of renewable energy. GPG may increase from the early 2030s and peak demand may experience significant growth, particularly in winter.(AEMO Gas Statement of Opportunities, 2024). Increases in the variability of peaking gas generation, combined with electrification efforts impact on overall gas demand may result in an overall peakier or more volatile gas demand. Electrification projections and overall projections of gas demand are included in AEMO GSOO 2024.
M19	Gas Sector	POLICY: Changes or cessation of recent gas policy measures aimed at capping prices and making more gas available from LNG producers. Gas supply code of conduct effective price cap at $12/GJ. Gas Supply heads of agreement with QLD LNG producers to ensure domestic supply. Gas Supply moratoria in east coast gas regions.	Changes to key gas policy settings impact cost and availability of gas	1. Affordability: Increase in overall cost of gas. 2. Emissions: Less gas available to flow to Victorian during periods of peak demand (combined with the event of issues with Gippsland production, and faster than expected Gippsland production declines)	Minor	Major	Minor	Major	Major	Possible	Medium	Gas code of conduct (has price limiting measures). https://www.accc.gov.au/business/industry-codes/gas-market-code Commonwealth government heads of agreement with LNG exporters. https://www.industry.gov.au/mining-oil-and-gas/oil-and-gas/securing-australian-domestic-gas-supply
M20	Gas Sector	TECHNOLOGY: Hydrogen gas blending technological constraint. Hydrogen blending at levels above 10% may not feasible in all pipelines or networks. May also have a bearing on capacity of network needed. 10% blend costs 7% in energy delivery (hydrogen carries one third the energy of natural gas).	Technical limitations on hydrogen blending in gas networks	1. Emissions: Emissions reductions in gas network attributable to hydrogen lag targets	Major	Minor	Minor	Major	Major	Possible	Medium	Australian Hydrogen Council (2022). Safety considerations of blending hydrogen in existing gas networks. https://h2council.com.au/wp-content/uploads/2022/10/EPRI_Safety_of_Hydrogen_Pipeline_Blending_2019_3002017253.pdf
M21	Transport sector	TECHNOLOGY: Inability to locate or justify use of alternative aviation fuels with lower or zero emissions compared with aviation turbine fuel (avtur). ECONOMICS: Renewable aviation fuel economics still uncertain	Civil aviation emissions not reduced	1. Emissions: Insufficient reduction in civil aviation emissions (1.7mt in 2025) to meet overall Victorian targets. Lost opportunity to reduce emissions	Major	Insignificant	Insignificant	Insignificant	Major	Possible	Medium	SEAM model for projections and NGERS data for actuals emissions data. Commonwealth state and territory greenhouse gas inventories. https://www.dcceew.gov.au/climate-change/publications/national-greenhouse-accounts-2020/state-and-territory-greenhouse-gas-inventories-data-tables-and-methodology National Greenhouse and Energy reporting scheme data. https://www.dcceew.gov.au/climate-change/emissions-reporting/national-greenhouse-energy-reporting-scheme

LOW AND VERY LOW RISKS

Low					Risk Assessment (with current controls) Severe, Major, Major, Minor or Insignificant							
					Consequences							
Risk ID	Risk Category (energy sector)	Cause	Risk Event	Risk Impacts/Consequences if the risk event occurs	Impact on Emissions	Affordability (consumer)	Social Equity	Reliability, Security and Safety	Highest	Likelihood	Risk Rating	Basis of Evaluation / Supporting Documentation
VL1	Electricity Sector	TECHNOLOGY: Technology does not currently support widespread V2G CONSUMER PREFERENCES: Incentives may not be sufficient to support V2G ECONOMICS: May not be significant benefit to V2G versus normal EV operation	EV Vehicle to Grid (V2G) penetration not as high as projected	1.Emissions: Lower EV V2G than expected would mean more peaking generation required. Impact by 2030 would be low given low level of V2 G assumed in ISP. 0 by 2030, and 3 GW by 2050. Is a longer term risk	Minor	Minor	Minor	Minor	Minor	Unlikely	Very Low	https://arena.gov.au/assets/2024/02/ARENA-Vehicle-to-Grid-Insights-Final-Report.pdf
L1	Electricity Sector	ECONOMICS: Electrolyser costs are still high, cost trends may not come down as much as anticipated. Green H2 also depends on cheap power. This may not be available on the scale, and capacity factor required to make this viable. SUPPLY CHAIN: Green Hydrogen industry is new. Availability of workforce and other key elements of supply chain is uncertain. INVESTMENT: Green Hydrogen supply chain requires significant investment to reach scale. INFRASTRUCTURE: New industry requires supporting infrastructure to enable build, and take hydrogen from production facilities to end users.	Economic viability and scale of green hydrogen supply as Gas Powered Generation (GPG) fuel and natural gas replacement	1. Emissions. Green hydrogen industry at scale and economic cost, can displace natural gas emissions 1. Security and reliability. Green hydrogen industry, combined with GPG, or reducing tariff V and D load for gas, can take pressure off natural gas supplies, supporting security and reliability	Major	Minor	Minor	Major	Major	Unlikely	Low	A number of reports discuss the challenge of hydrogen as a source of energy from a cost point of view, particularly in the near term. Reference: Grattan's report getting off gas, figure 1.4 "Hydrogen cant match gas on price".
L2	Electricity Sector	ECONOMICS: Economy ics of hydrogen use cases may improve thereby driving development POLICY: Policy to support green hydrogen development or hydrogen production and consumption targets would driver higher demand for electricity for hydrogen production	Electricity demand for hydrogen electrolysis higher or lower than expected	1. Affordability: High demand for hydrogen from grid, may increase the overall delivered cost of electricity for all consumers. However, green hydrogen industry at scale is unlikely without long term cheap power	Major	Major	Major	Major	Major	Unlikely	Low	Potential development of hydrogen electrolysers is forecast to increase NEM electricity consumption by up to 10% by 2032-33, assuming that electrolysers operate to provide new energy options to consumers, including potential hydrogen-ready gas generators that are not yet advanced enough to consider in the Central scenario. ESOO The forecast for hydrogen electrolysis development has increased significantly since the 2022 ESOO as outlined in the Australian Energy Market Operator (AEMO) 2023 Electricity Statement of Opportunities (August 2023)
L3	Electricity Sector	POLICY: Shift in government policy to also deploy carbon price alongside CIS and renewables targets	Risk or opportunity posed by Introduction of carbon price	1. Emissions: Would accelerate retirement of coal, and decarbonisation of gas supply where used for electricity sector. Would also accelerate decarbonisation of gas supply for use in the gas market 2. Affordability: Carbon price would lead to higher delivered cost of energy in the near term, with carbon priced into retail bills	Major	Major	Major	Minor	Major	Unlikely	Low	Internal assessment. At present no carbon price is applied to the electricity, gas or transport sectors, although carbon pricing is effectively applied to some businesses through the safeguard mechanism. The electricity sector is covered under a sector wide cap in the mechanism, and provided this is not breached, as it hasn't been to date, individual carbon targets are not applied to generators. If a carbon price were applied to the electricity sector, it would impact the costs of different generators operating in the NEM.
L4	Electricity Sector	CONSUMER PREFERENCES: Insufficient support, insufficient incentives, providing communities with new technology for energy transition of community microgrids. SUPPLY CHAIN: Supply of renewable technology to microgrids may be more challenging in terms of the availability of technology in remote locations. ECONOMICS: Renewables development for microgrids may not always be economically feasible without clear supporting incentives	Community microgrids do not transition to clean energy supply	1. Emissions: Decarbonisation of microgrids slowed 2. Affordability: Decarbonised microgrids likely to provide cheaper power longer term, given cost of supply chain to deliver thermal power to microgrids	Minor	Minor	Major	Minor	Major	Unlikely	Low	Commonwealth policy: Community microgrid and sustainable energy program supports installation of solar, batteries and DER for range of buildings. To provide reliable power supply and build energy resilient rural communities. Commonwealth policy: Microgrid demonstration initiative supports development of microgrid demonstration projects
L5	Electricity Sector	COMMUNITY ACCEPTANCE: Major accidents early in industry development have huge reputation risk, threatening technology take up. Early incidents may have a significant impact on take up rates	Safety incidents with new technology such as hydrogen and batteries slows uptake	1. Emissions: Lag in uptake rates rooftop batteries and hydrogen developments	Minor	Minor	Minor	Major	Major	Unlikely	Low	15.03.2024 Guardian reports four lithium battery fires in a day (in NSW). Growing rumours that fire crews do not have ability to manage lithium battery fires. Hydrogen has well known explosive qualities (Hindenburg) and noted explosions at refuelling centres where safety procedures have not tackled issues.
L6	Transport sector	ECONOMICS: High cost of electrical reticulation (overhead catenary) and low level of development of battery electric locomotives to replace use of diesel in locos	Railway emissions not reduced	1. Emissions: Insufficient reduction in rail emissions (0.4mt in 2023) to meet overall Victorian targets. Lost opportunity to reduce emissions	Minor	Insignificant	Insignificant	Insignificant	Minor	Possible	Low	SEAM model for projections and NGERS data for actuals emissions data. Commonwealth state and territory greenhouse gas inventories. https://www.dcceew.gov.au/climate-change/publications/national-greenhouse-accounts-2020/state-and-territory-greenhouse-gas-inventories-data-tables-and-methodology National Greenhouse and Energy reporting scheme data. https://www.dcceew.gov.au/climate-change/emissions-reporting/national-greenhouse-energy-reporting-scheme#:~:text=The%20National%20Greenhouse%20and%20Energy,energy%20production
L7	Transport sector	ECONOMICS: Economics of renewable fuel use in maritime sector is uncertain INFRASTRUCTURE: Low level of usage and infrastructure available for lower emission maritime fuels (e.g. ammonia, ethanol)	Maritime transport emissions not reduced	1. Emissions: Insufficient reduction in navigation emissions (0.3mt in 2023) to meet overall Victorian targets. Lost opportunity to reduce emissions	Minor	Insignificant	Insignificant	Insignificant	Minor	Possible	Low	SEAM model for projections and NGERS data for actuals emissions data. Commonwealth state and territory greenhouse gas inventories. https://www.dcceew.gov.au/climate-change/publications/national-greenhouse-accounts-2020/state-and-territory-greenhouse-gas-inventories-data-tables-and-methodology National Greenhouse and Energy reporting scheme data. https://www.dcceew.gov.au/climate-change/emissions-reporting/national-greenhouse-energy-reporting-scheme#:~:text=The%20National%20Greenhouse%20and%20Energy,energy%20production

Appendix E Mitigation action assessment

APPENDIX E MITIGATION ACTION ASSESSMENT

Line					Risk Assessment (with current controls) Severe, Major, Major, Minor or Insignificant										Mitigation action addresses which risk aspect (highlight in yellow)					
					Consequences										Consequences					
Risk ID	Risk Category (energy sector)	Cause	Risk Event	Risk Impacts/Consequences if the risk event occurs	Impact on Emissions	Affordability (consumer)	Social Equity	Reliability, Security and Safety	Highest	Likelihood	Risk Rating	Basis of Evaluation / Supporting Documentation	Proposed Mitigation Actions	Mitigation action addresses: impact category and/or likelihood	Emissions	Affordability	Social equity	Reliability, security, safety	Highest	Likelihood
VH1	Electricity Sector	INVESTMENT: VRE Delays. Failure to meet VRE build target in the timeframe. Refer to risk event "REZ DEVELOPMENTS V1-V8 ARE DELAYED, NOT DEVELOPED TO PLANNED ISP CAPACITY" INVESTMENT: BESS and Storage delays. Failure to meet clean dispatchable power targets lead to concerns around affordability, grid stability and reliability INVESTMENT: Transmission delays. Concerns around affordability, grid stability and reliability due to lack of interconnection, or delays in major transmission projects (regulatory, supply chain) and decision making COMMUNITY ACCEPTANCE: Community concerns that renewables and storage are not able to provide reliable and affordable power through the transition from coal to renewables.	THERMAL POWER PLANTS ARE RUN LONGER THAN EXPECTED (as per ISP)	1.Emissions: Emissions targets may not be achieved 2. Security and Reliability: Reliance on ageing infrastructure could pose reliability risks (power outages) if not managed effectively 3. Affordability: In the near term, coal plant extensions may provide for lower or more stable prices. 4. Environmental Impact: An increased contribution to climate change and its associated widespread adverse impacts and related losses and damages to nature and people beyond natural climate variability. 5. Economic Impacts: Delayed retirements in order to maintain lower energy prices may impact investment decisions in renewable energy infrastructure. It may also require more maintenance expenditure longer term or have economic impacts through lower reliability, such as the cost to the economy of power outages, as plants age. 6. Public Perception and community acceptance: If deferrals are perceived as favouring vested interests over public welfare or environmental goals, it could erode trust in energy policies and decision-makers.	Severe	Minor	Minor	Minor	Severe	Likely	Very High	Victoria has to accelerate development of renewable energy, distributed PV and onshore wind in mid term and offshore wind and industrial wind in the long term to reach ODP under the draft ISP 2024. Policies to achieve this are Renewable Energy Target Scheme and Commonwealth Capacity Investment Scheme (CIS). Announced retirement dates (or expected dates based on current announcements) are currently well after the dates modelled: Victoria, Government of. (2023, August 23). Agreement Secures Transition for Loy Yang A. Premier of Victoria Energy Australia (2021). Energy Australia power ahead with energy transition Australian Energy Market Operator (AEMO). (2024). Generation information. Generating unit expected closure year file - February 2024 IPCC AR6 WGII Summary for policy makers	1. Continue implementation of VRET and/or CIS to support the build-out of the renewable resources in Victoria (beyond 2030)	Likelihood	Severe	Minor	Minor	Minor	Severe	Likely
H1	Electricity Sector	DEMAND CHANGES: Growing demand for electricity due to factors including population growth, increased urbanisation, and economic development. INFRASTRUCTURE: Geographical differences: Investment and capacity development is not always equal across geographic areas. TECHNOLOGY: Rapid Technological Changes: The rise of rooftop photovoltaic (PV) systems, electric vehicles (EVs), and electrification loads (such as heat pumps) will significantly impact electricity demand and the need to accommodate rooftop PV.	INADEQUATE MANAGEMENT OF ADDITIONAL LOADS AND FLOWS ON DISTRIBUTION NETWORK.	1. Emissions: Slower growth in rooftop PV and electrification due to network limitations will impact emissions 2. Affordability: Some networks may not allow for required growth in rooftop PV, EVs and electrification on the ISP planned timescale, these are all measures that act to reduce consumer bills. 3. Security and reliability: Voltage Instability: Insufficient network capacity can lead to voltage fluctuations and instability. When the distribution network is unable to handle the load from rooftop photovoltaic (PV) systems, electric vehicles (EVs), and electrification loads, it can result in overloaded transformers, substations, and power lines. Overloading can cause equipment failures and blackouts. 4. Safety: Overloaded infrastructure poses safety risks. For example, overheated transformers or power lines can lead to fires or electrical accidents. 5. Social Equity or regional impacts. Regional disparities may grow as some network areas will have more spare capacity to allow for rooftop PV growth and increasing load, than others.	Major	Major	Major	Major	Major	Likely	High	The AEMO's ESOO projects that the total electricity consumption in the NEM is forecast to increase significantly to account for electrification, EVs, rooftop PV, economic growth.. From the current level of approximately 195 terawatt-hours (TWh), the consumption is expected to surpass 420 TWh by the year 2049-50. Residential Consumption: Specifically, residential electricity consumption is projected to grow substantially. By 2050, residential consumption alone is estimated to reach 150 TWh. (AEMO, 2024) (AEMO, 2023, p. 3) The Solar Homes program is a 10-year initiative in Victoria designed to empower more than 770,000 households. It achieves this by providing rebates for solar photovoltaic (PV) systems, solar batteries, and solar hot water installations. Since its launch in August 2018, over 110,000 Victorians have accessed the Solar Homes program. Solar PV export constraints: Before applying for a Solar Homes PV rebate, eligible Victorians must ensure that their retailer has obtained pre-approval from the Distributed Network Service Provider (DNSP) to connect their solar system to the grid. Distribution businesses sometimes impose export limits on solar systems to maintain network voltages and manage reliability risks. As a result of insufficient capacity of distribution networks, the number of beneficiaries from these programs will be limited leading to undershooting AEMO targets. (Solar Victoria, 2020)	1. Coordinated state planning of capacity growth and/or demand management , required for all 5 electricity distribution networks in Victoria. 2. Develop demand response programs to help balance supply and demand in Victoria in a future with more extreme demand 3. Options to encourage battery uptake 4. Encouraging take-up of aggregated storage and other technologies that allow for centralised management of CER/ DER at times of high volatility Develop and implement policies to support digitalisation in the energy sector	Likelihood	Major	Major	Major	Major	Major	Likely
H2	Electricity Sector	DEMAND CHANGES: Low Minimum Demand: declining minimum operational demand influenced by factors such as rooftop solar generation. The level of minimum electricity demand is lower than anticipated, which affects the grid's capacity to accommodate offshore wind and other Variable Renewable Energy (VRE) resources. TECHNOLOGY: Offshore wind introduces a large source of renewable energy that may not be easy to accommodate during these minimum demand periods. This may lead to economic curtailment of VRE	CURTAILMENT OF VRE RESOURCES DUE TO LOW MINIMUM DEMAND LEVELS.	1. Emissions: Lost VRE output may mean higher overall emissions intensity of the NEM than would be the case if minimum demand periods could be managed and VRE not curtailed during low demand periods. 2. Affordability: Low demand periods lead to Economic curtailment and lost output from VRE impacting consumer bills.	Major	Major	Major	Major	Major	Likely	High	Growth of rooftop PV and projected low levels of minimum demand presents huge problems for AEMO. Requires quicker ramp up for generators, creating a risk of unit failures, also presents risk of unsecure operating state and risk of blackouts. Victoria will see growth in PV but also large amount of offshore wind generation capacity. Australian Energy Council (AEC). (2021). Is minimum demand causing a major headache	1. Accelerate renewable gas development pre-2030 2. Support the development of long duration storage.	Likelihood	Major	Major	Major	Major	Major	Likely
H3	Electricity Sector	POLICY: Historical Lack of Energy Efficiency Standards: Insulation standards were introduced in 1991 in Victoria and minimum energy efficiency requirements for new houses were introduced in 2003 through the Building Code of Australia . Many existing homes lack proper insulation and energy-efficient features. POLICY: Primary program supporting energy efficiency measures in Victoria is the VEU. Question of whether this program and changes under review in this program, such as the inclusion of insulation in the program, are sufficient to deliver the required reductions in energy consumption and the reductions in peak energy consumption. ECONOMICS: Upgrading energy efficiency of a home involves an upfront cost that can be a barrier for some. Additionally, some households cannot make physical changes to their home due to rental restrictions. Landlords may not invest in energy efficiency as they may not receive the benefits from the investment	HOUSEHOLDS DO NOT IMPROVE ENERGY EFFICIENCY OF THEIR HOMES AS MUCH AS PROJECTED.	1. Emissions: Less than expected energy efficiency uptake could increase emissions, or lead to missed opportunity to avoid emissions 2. Affordability: Increased Energy Costs for Households who do not implement energy efficiency measures. 3. Security and Reliability: Inefficient energy use, particularly during peak periods, places strain on energy infrastructure, including power grids and distribution networks. This can lead to reduced reliability, and increased maintenance costs. 4. Equity: Energy poverty disproportionately affects vulnerable populations, including low-income households, the elderly, and people with disabilities. Inadequate policies perpetuate social inequities, as those who can least afford high energy costs bear the brunt of inefficiencies. 5. Health and Well-Being Impacts: Inadequate energy efficiency can directly affect residents' health and well-being. Poor insulation, inadequate heating, or lack of cooling can lead to uncomfortable living conditions. Cold homes can contribute to respiratory illnesses, exacerbate existing health conditions, and impact mental health.	Major	Major	Major	Major	Major	Likely	High	CSIRO data on the NatHERS star rating distribution indicates that 65.4% of Class 1 dwellings in Victoria are 2 stars or below – this equates to a stock of 1,367,766 sub-standard homes. https://www.sustainability.vic.gov.au/research-data-and-insights/research/research-reports/the-victorian-healthy-homes-program-research-findings The VEU program is expected to deliver around 78.5 million tonnes of greenhouse gas emissions savings since it began in 2009. (Essential Services Commission, 2023) Under the sensitivity analysis, the total renewable energy share would be only 63% by 2030, less than the 82% target, and NEM emissions would overshoot their 2029-30 emissions targets by approximately 155Mt CO2-e 33 . (Australian Energy Market Operator, 2024) The Gas Substitution Roadmap reports over 2 million Victorians currently use gas in their homes and businesses, making it crucial to address its environmental impact. The Victorian gas sector contributes approximately 17% of the state's net greenhouse gas emissions. Households may hesitate to adopt energy efficiency measures due to initial costs associated with transitioning from gas to electric appliances. These costs include purchasing new equipment, installation, and potential modifications to existing infrastructure. (Department of Energy, Environment and Climate Action, 2024)	1. Encouraging take-up of aggregated storage and other technologies that allow for centralised management of CER/ DER at times of high volatility 2. Develop and implement policies to support digitalisation in the energy sector	Likelihood	Major	Major	Major	Major	Major	Likely
H4	Electricity Sector	CONSUMER PREFERENCES: Consumer incentive for battery installation is not yet as compelling as solar PV. COMMUNITY ACCEPTANCE: Growing commentary in the press on the risk of fires with distributed batteries. COMMUNITY ACCEPTANCE: Hesitance on part of consumers to provide permission to government of institutions to control their DER (Distributed Energy Resources) systems, above and beyond that required by law.	LACK OF CUSTOMER TAKE UP OF EMBEDDED AND AGGREGATED STORAGE.	1. Emissions: Rooftop PV penetration is slowed down by technical limitations at network level leading to reduction or delay in low emissions consumer resources deployed. 2. Security and Reliability: Distribution networks will require greater levels of augmentation the lower the level of storage at the distributed level, to meet rooftop PV and max demand requirements. 3. Security and Reliability: Inadequate energy storage deployment can result in grid instability during peak demand periods. Without sufficient storage capacity, managing fluctuations in energy supply becomes challenging. 4. Security and Reliability: Aggregated storage may allow for more centralised control and visibility on distributed resources. Lower take up would see less visibility, less predictable and controllable power system.	Major	Major	Minor	Major	Major	Likely	High	CER quarterly carbon market report shows 8% of new installations have a battery installed as well. AEMC report on incentives for batteries in 2023 shows incentives for battery investment still finely balanced for Tesla batteries, but incentives are dependent on future tariff structures. Clean Energy Regulator. (2023). Quarterly Carbon Market Report: December Quarter 2023. https://cer.gov.au/markets/reports-and-data/quarterly-carbon-market-reports Australian Energy Market Commission (AEMC). (2023). Turning point for incentives to invest in residential batteries. https://www.aemc.gov.au/turning-point-incentives-invest-residential-batteries	1. Options to encourage battery uptake	Likelihood	Major	Major	Minor	Major	Major	Likely
H5	Electricity Sector	TECHNOLOGY: As coal generators age, they may not be as well maintained given operators plans to close stations and the high cost of refurbishment. Evidenced by recent coal station reliability issues. ECONOMICS: Economics of refurbishment may be challenging with end of asset life in sight.	INCREASE IN COAL FIRED POWER OUTAGES	1. Affordability: Energy Shortages: As aging coal-fired generators experience more frequent breakdowns and extended maintenance periods, there is a higher risk of energy shortages and prolonged extreme high prices. 2. Affordability: Increased Reliance on Gas and Imports: When coal generators are out of service, the grid relies more heavily on gas-fired power stations and electricity imports from neighbouring states. This increased reliance on gas can strain the gas supply network and impact energy prices. 3. Reliability: Frequent breakdowns and prolonged maintenance periods impact the overall reliability of the electricity grid. Sudden outages can lead to voltage fluctuations, affecting sensitive equipment and causing disruptions.	Minor	Major	Minor	Severe	Severe	Possible	High	Callide C failure in 2022 illustrates the risks. AEMO has made assessment of the impact of ageing coal assets on reliability. Australian Energy Market Operator (AEMO). (2020). Assessment of ageing coal fired generation reliability AEP Elical. https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/inputs-assumptions-methodologies/2020/aep-elical-assessment-of-ageing-coal-fired-generation-reliability.pdf?la=en	1. Coordinated state planning of capacity growth and/or demand management for all 5 electricity distribution networks in Victoria. 2. Support the development of long duration storage.	Likelihood	Minor	Major	Minor	Severe	Severe	Possible
VH2	Electricity Sector	INVESTMENT: Offshore wind projects require substantial capital investment, even with Government auction process, the high capital outlay and long/complex planning processes required may deter potential investors or delay development. ECONOMICS: High Capital costs, and changes in capital cost projections may result in project delays TECHNOLOGY: The marine environment off the coast of Victoria can pose challenges. Factors such as strong currents, wave heights, and seabed conditions affect the feasibility and safety of offshore wind installations. Complex engineering designs are necessary for offshore wind turbines, foundations, and transmission infrastructure. Technical challenges related to installation, maintenance, and grid integration can lead to delays or cost overruns. CLIMATE CHANGE: Extreme weather events can damage equipment, delay construction or impact operational efficiency SUPPLY CHAIN: Availability of skilled labour, specialized vessels, and equipment for offshore construction is critical. Delays in procuring components or logistical challenges can affect project timelines and costs. SUPPLY CHAIN: Questions around suitable ports being identified to support offshore wind developments COMMUNITY ACCEPTANCE: Public perception, community consultations, and stakeholder engagement play a significant role. Opposition from local communities or concerns about visual impact, noise, and fishing activities can hinder project progress. ENVIRONMENT/SUSTAINABILITY: Potential impacts on the marine environment or biodiversity hinder or delay project approvals	OFFSHORE WIND TARGETS NOT MET	1. Emissions: Delays might result in a prolonged reliance on coal-based energy sources, hindering the transition to renewable energy targets set by the government. 2. Reliability and Security: Delays or reductions in offshore wind capacity would see less energy available in the Victorian energy system and less diversity in the supply sources available. While wind is not a firm source of energy, it diversifies sources of energy in Victoria.	Severe	Major	Minor	Minor	Severe	Likely	Very High	CSIRO reports the anticipated capital costs for offshore wind installations in 2028 are estimated to be $5356 per kilowatt of installed capacity, nearly three times higher than the corresponding cost for onshore wind, which stands at $1915 per kilowatt. (CSIRO, 2023) AEMOS's Draft ISP states that significant reductions in costs would be needed for offshore wind to feature in the energy mix. (Australian Energy Market Operator, 2024) Rising inflation, supply chain disruption from turbine manufacturing requirements, high interest rates and lengthy waiting times for permits and grid connections all contribute to increased timelines and budgets for offshore wind projects. Over $30 billion in investment has been deferred due to delays in at least 10 offshore wind projects across the United States and Europe. Swedish company Vattenfall estimate costs of building offshore wind farms have increased 40% in 2023. (Financial Review, 2022) The winds of change: using marine spatial planning to create a responsible, nature-positive offshore wind industry. vnpa.org.au/publications/winds-of-change	1. Comprehensive and sustained public communications campaign that links all of the transition pieces together 2. Implement a comprehensive energy transition workforce investment plan 3. Continue implementation of VRET and/or CIS to support the build-out of the renewable resources in Victoria (beyond 2030) 4. Accelerate investment commitment to port Infrastructure 5. Improving community acceptance and supporting approvals of major energy infrastructure projects 6. Develop alternatives (an adaptive plan) to manage offshore wind delay	Consequence: Emissions & Affordability Likelihood	Severe	Major	Minor	Minor	Major	Likely
VH3	Electricity Sector	CLIMATE CHANGE: Increase in number of extreme heat events. DEMAND CHANGE: Population growth will also see overall load increase and constraints on local distribution networks, further increasing the impact of extreme demand events	MORE FREQUENT EXTREME CLIMATE WEATHER EVENTS INCREASE FREQUENCY AND UNPREDICTABILITY OF PEAK DEMAND EVENTS	1. Emissions: Higher peak electricity demand may mean increased thermal generation (coal, natural gas), leading to higher emissions. 2. Security and Reliability: 1 in 20 or 1 in 50 year events now occur more often, requiring greater generation and network investment. During extreme heatwaves, the strain on the electricity grid can lead to supply shortages. Insufficient supply may result in rolling blackouts or localised power outages, affecting homes, businesses, and critical infrastructure. 3. Security and Reliability: The electricity grid faces increased stress during peak demand periods, potentially leading to equipment failures or reduced reliability. Transformers, substations, and distribution lines may be impacted by extreme heat, affecting overall system performance. 3. Social Equity: Vulnerable communities may struggle to afford air conditioning or cope with extreme heat. Disparities in access to cooling resources can widen during heatwaves.	Minor	Major	Minor	Severe	Severe	Likely	Very High	The number of very hot days (>40 °C) will increase from 0.83 to 2.7 days per year in Melbourne, and from 7.8 to 17 days per year in Mildura. The CSIRO reports that there has been an increase in the frequency of months that are hotter than usual. In the period from 1960 to 1989, monthly maximum temperatures that were considered very high occurred approximately 2% of the time. However, in the more recent period from 2007 to 2021, these same very high temperatures now occur over 11% of the time. This significant increase highlights the impact of climate change on temperature extremes. (CSIRO, 2022)	1. Comprehensive and sustained public communications campaign that links all of the transition pieces together 2. Develop demand response programs to help balance supply and demand in Victoria in a future with more extreme demand 3. Options to encourage battery uptake 4. Encouraging take-up of aggregated storage and other technologies that allow for centralised management of CER/ DER at times of high volatility 5. Develop and implement policies to support digitalisation in the energy sector	Consequence: Reliability, security, safety	Minor	Major	Minor	Severe	Severe	Possible
H6	Electricity Sector	CLIMATE CHANGE: Climate change is significantly increasing the risk of bushfires in Victoria. The fire season has lengthened, now spanning from October to March, due to hotter days and more frequent heatwaves. Drought conditions have intensified in Australia's southeast, exacerbating fire risk. These changes in climate contribute to an increase in dangerous fire weather, leading to more frequent and severe bushfires. CLIMATE CHANGE: Heatwaves, wildfires, cyclones, and floods, pose a significant challenge to electricity systems. These extreme events are a significant cause of large-scale outages. Noting recent large scale outages in Victoria.	EXTENSION OF FIRE SEASON REDUCES GENERATION AND TRANSMISSION RELIABILITY, EXTREME WEATHER IMPACTS TRANSMISSION RELIABILITY	1. Security and reliability: Extended fire seasons pose a significant threat to the power grid, transmission and generation, infrastructure. The network infrastructure (including transformers, switchgear, and distribution lines) is at risk. Substation fires can disrupt electricity flow, affecting multiple areas simultaneously. 2. Security and reliability: Collapsed power lines, damaged substations, and tower collapses may require extensive repairs. Repairing and restoring the network can be time-consuming and costly. 3. Economic Impact: Extended power outages can lead to financial losses for businesses. Manufacturing, retail, and other sectors may suffer due to production halts or reduced operations. Loss of revenue, increased operational costs, and damage to equipment can strain the economy. 4. Health and Safety Risks: Hospitals, emergency services, and medical facilities rely on uninterrupted power. Outages can jeopardize patient care, medical equipment, and life-saving procedures.	Major	Major	Minor	Severe	Severe	Possible	High	Victoria can expect longer fire seasons, with around 40% more very high fire danger days (Climate Change in Australia, n.d.). In 13 Feb 2024 a storm in Victoria led to 135,000 Victorians without power. State energy minister called for national approach to weatherproof the electricity grid. Severe weather led to the collapse of six 500 kV towers on the Moorabool to Sydenham lines. this tripped Loy Yang A. (Guardian) Climate Change in Australia. (n.d.). Victoria - Climate Change in Australia. https://www.climatechangeinaustralia.gov.au/en/changing-climate/state-climate-statements/victoria/ Guardian (2024). Thousands of Victorian remain without electricity as inquiry launched into mass power outages. https://www.theguardian.com/australia-news/2024/feb/20/victoria-power-outages-electricity-latest-news-updates-restoration-inquiry-launched	1. Develop demand response programs to help balance supply and demand in Victoria in a future with more extreme demand	Consequence: Reliability, security, safety	Major	Major	Minor	Severe	Severe	Possible
H7	Electricity Sector	TECHNOLOGY: Retirement of thermal generation: The retirement of thermal generation leads to a lack of ability to provide firming generation. TECHNOLOGY: During Dunkelflaute, there is a lack of both solar and wind energy production. This can happen due to prolonged overcast conditions or calm weather, resulting in reduced electricity output from renewable sources. TECHNOLOGY: While batteries are useful for managing daily fluctuations, they are not well-suited for longer durations. Most batteries have less than four hours of storage capacity. DECLINING GAS RESERVES: Gas Shortfalls: GSOO shows seasonal shortfall in gas supply from 2026 and annual shortfalls from 2028	INADEQUATE LONG DURATION STORAGE IN TIME FOR COAL EXIT	1. Emissions: Relying on non-renewable firming options (like gas peaker plants) during Dunkelflaute can have environmental consequences. It may increase greenhouse gas emissions, offsetting the benefits of renewable energy. 2. Security and Reliability: Dunkelflaute poses reliability challenges for the market. The market must find alternative sources of power to meet demand during these periods. If not managed effectively, it can lead to blackouts or load shedding in extreme scenarios and prolonged periods of very high prices in others. 3. Affordability: Increased Costs: To address Dunkelflaute, additional firming technologies are needed to supply the grid at low capacity factors. These technologies (such as batteries, pumped hydro, or gas peaking or hydrogen capable gas peaking plants) come with high cost to provide long duration energy storage. To the extent solutions are not fully developed, this may lead to extended periods of high prices during winter where the system as a whole is short of energy.	Major	Major	Minor	Major	Major	likely	High	GSOO 2024 shows seasonal shortfall in gas supply from 2026, driven by declining supply in southern basins, and increasing demand for gas for GPG Australian Energy Market Operator (AEMO). (2024). 2024 Gas Statement of Opportunities	1. Support the development of long duration storage. 2. Develop demand response programs to help balance supply and demand in Victoria in a future with more extreme demand 3. Implement comprehensive support measures for the development of Electric Vehicle (EV) charging facilities	Consequence: Reliability, security, safety Likelihood	Major	Major	Minor	Major	Major	Likely
VH4	Gas Sector	DECLINING GAS RESERVES: Rapid decline in Victorian and southern gas basin production capacity and reserves. GSOO identifies peak supply issues on extreme demand days from 2025, seasonal supply gaps under high winter demand from 2026 and 2027 and annual supply gaps from 2028. DEMAND CHANGES: GSOO forecasts annual GPG consumption to increase from the early 2030s, with significant growth in peak day consumption. POLICY: Commonwealth price caps (through the mandatory Code of Conduct) discourage investment in new supply and regas terminal economics. Government released new acreage for offshore gas exploration in 2018 and 2020. There is a ban on unconventional gas production onshore. COMMUNITY ACCEPTANCE: Opposition in Victoria to offshore drilling.	PEAK AND ANNUAL GAS SUPPLY SHORTFALLS	1. Emissions: The gas sector plays a crucial role in Victoria's energy transition. Any disruptions due to gas shortages could hinder progress toward this goal, including through delays to coal retirements 2. Affordability: More peak price events with scarcity pricing. 3. Security and Reliability: Physical shortfalls of gas, particularly where winter peaking gas system demand coincides with high electricity demand and unplanned outages to coal plants. Increased likelihood of outages of gas plants as there is less redundancy in the gas system as supply declines. 4. Equity: Potential for certain groups to be disproportionally impact if they have not been in a position to electrify their residence	Minor	Severe	Minor	Severe	Severe	Likely	Very High	AEMO 2024 GSOO shows risk of shortfalls on some days in winter in Southern Australia under extreme peak conditions. From 2026 and 2027, potential for seasonal supply gaps, from 2028, forecast annual supply gaps as southern production declines. (Australian Energy Market Operator, 2024)	1. Develop demand response programs to help balance supply and demand in Victoria in a future with more extreme demand 2. Initiate a planning assessment and feasibility for alternative gas supply options to resolve potential shortfalls occurring in 2026–2028 and over the longer term 3. Extend and budget for government bill support for consumers impacted with higher bills in predicted gas shortfall years. (2025–2030)	Consequence: Affordability & Reliability, security, safety Likelihood	Minor	Severe	Minor	Severe	Severe	Likely

Low					Risk Assessment (with current controls) Severe, Major, Major, Minor or Insignificant										Mitigation action addresses which risk aspect (highlight in yellow)					
					Consequences										Consequences					
Risk ID	Risk Category (energy sector)	Cause	Risk Event	Risk Impacts/Consequences if the risk event occurs	Impact on Emissions	Affordability (consumer)	Social Equity	Reliability, Security and Safety	Highest	Likelihood	Risk Rating	Basis of Evaluation / Supporting Documentation	Proposed Mitigation Actions	Mitigation action addresses: impact category and/or likelihood	Emissions	Affordability	Social equity	Reliability, security, safety	Highest	Likelihood
VH5	Gas Sector	ECONOMICS: The transition to electric appliances and systems can be costly for consumers. This includes the upfront costs of purchasing new electric appliances and the potential costs of upgrading electrical systems in homes. COMMUNITY ACCEPTANCE: While electrification can lead to long-term savings on energy bills, these savings may not be immediately apparent to consumers. The perceived lack of immediate financial benefit can deter consumers from making the switch. COMMUNITY ACCEPTANCE: Consumers may not switch to electric if they are not aware of all the benefits of electrification, including environmental benefits POLICY: Policy such as the Victorian Government's Energy Upgrades scheme may not offer rebates sufficient to encourage and maintain assumed rate of electrification	EXISTING GAS CUSTOMERS DON'T ELECTRIFY TO THE ANTICIPATED LEVEL PER THE ISP	1. Emissions: A reduced pace of electrification than planned could impact Victoria's ability to meet its climate goals and reduce greenhouse gas emissions. 2. Affordability: Consumers who don't electrify may miss out on savings through lower energy bills 3. Affordability: Continued use of gas appliances means continued dependency on fossil fuels. This not only has environmental implications but also leaves consumers exposed to fluctuations in international gas prices. As gas reserves decline, dependency on gas imports from northern regions or regas terminals may grow. 4. Equity: Potential for certain groups to be disproportionally impacted	Severe	Major	Major	Minor	Severe	Likely	Very High	There is a significant cost to fully electrify existing households and they will not change without a government incentive. Some households and small businesses prefer gas and will not transition quickly The Victorian Energy Upgrades program has expanded to offer incentives of up to $3,600 to install a wider range of efficient electric appliances such as heat pumps and reverse cycle air conditioners, while previous incentives for gas appliances have been phased out. Incumbent industry, such as gas networks (AGIG), continue to push for gas use to support viability of their assets longer term. Plumbers may push residential homes to stay with gas in order to protect their businesses. Electric appliances are often more expensive to purchase than gas alternatives, even with government incentives, this inconvenience and cost associated would dissuade many homes from switching, prolonging the timeline to zero gas reliant homes.(Grattan Institute, 2023) With 5 million households in Australia relying on gas, and Victoria being the most reliant state, 200 households a day would need be fully phased out of the network to reach the goal of zero reliant homes by 2050. (Grattan Institute, 2023)	1. Comprehensive and sustained public communications campaign that links all of the transition pieces together 2.Implement a comprehensive energy transition workforce investment plan 3.Planning and support for consumer electrification: -Develop a carefully phased plan -Undertake a targeted communications campaign on the benefits and timetable for upgrading to all electric (electrification) -Consumer financial incentives for electrification, and transition away from household gas devices and incentives for landlords to electrify and move away from household devices 4. Support for industrial supply chains to electrify gas consumption where feasible	Likelihood	Severe	Major	Major	Minor	Severe	Likely
H8	Gas Sector	DEMAND CHANGES: As consumers shift toward cleaner energy sources, the demand for natural gas may decrease. Gas assets built for a larger customer base could become underutilised, impacting their financial viability. ECONOMICS: High operational and maintenance costs, which may increase as assets age.	SPIRALING GAS NETWORK COSTS FOR REMAINING GAS CONSUMERS.	Affordability: Gas consumers remaining on the network pay more for gas network services as gas asset owners seek to recoup cost of assets Social Equity: Consumers and gas users who are unable to switch away from gas pay a disproportionate burden for the continued maintenance and operation of the asset.	Minor	Major	Major	Insignificant	Major	Likely	High	The AER has identified how the decline in gas demand can have several impacts. First, reduced gas connections mean fewer customers to share fixed costs, potentially leading to increased prices. Second, the burden of unpaid past investments may shift to future gas customers. Third, there's a risk of economic stranding for gas networks. Finally, price volatility and uncertainty could further reduce demand, exacerbating the unequal distribution of cost burdens. (Australian Energy Regulator, 2023) The Australian Energy Regulator (AER) has decided to narrow the price gap between temporary and permanent gas disconnection services by setting a charge of $220 for the disconnecting consumer, with the remaining costs of the permanent gas disconnection service being recovered through the networks' haulage tariffs spread across all gas consumers.(Department of Energy, Environment and Climate Action, 2024) (Energy Networks Australia, 2021) ECA commissioned report on the risks to gas consumers of declining demand. Energy Consumers Australia (2022). Risks to gas consumers of declining demand (Boardroom energy)	1. Accelerate renewable gas development pre-2030	Likelihood	Minor	Major	Major	Insignificant	Major	Likely
VH6	Gas Sector	ECONOMICS: The economics of renewables gases including biomethane and hydrogen are challenging, at least in the near term. Higher production costs and infrastructure development expenses can be deterrents. INFRASTRUCTURE: Building the necessary infrastructure for renewable gas production, storage, and distribution is capital-intensive. Existing natural gas infrastructure is not always compatible with renewable gas INVESTMENT: Investors seek stable regulatory environments. Policy gaps create uncertainty, affecting investment decisions. Capital flow into renewable gas projects may be limited. TECHNOLOGY: Developing efficient and cost-effective methods for producing renewable gas (such as electrolysis for hydrogen or anaerobic digestion for biomethane) is an ongoing challenge. TECHNOLOGY: Investment in renewable gas R&D may decline COMMUNITY ACCEPTANCE: Lack of awareness about renewable gas and its benefits can lead to limited public support and political will. Public perception may not fully recognise the potential of renewable gas as a clean energy solution. POLICY: A lack of policy backing may lead to scepticism and resistance. ENVIRONMENT/SUSTAINABILITY: Perception of development and use of renewable gases such as hydrogen and biomethane as 'greenwashing'	LACK OF RENEWABLE GAS DEVELOPMENTS	1. Emissions: Missed opportunities in decarbonisation making it more challenging to meet the emissions targets. 2. Energy Security and Reliability: Missed opportunity to diversify energy sources and thereby improve security and reliability 3. Technology: Breakthroughs in technology and efficiency could be delayed leading to delays in renewable gas availability	Severe	Major	Major	Major	Severe	Likely	Very High	2024 GSOO shows reduction in natural gas demand if uncertain hydrogen and biomethane is developed. Shows 30 PJ by 2035, and 15 PJ by 2030. (Australian Energy Market Operator, 2024) VGPR 2024, table 22, shows a summary of primary barriers to increased production of renewable gas, and its use. Includes lack of a unified approach, lack of carbon abatement recognition, lack of targets, financial risks of market entry. (Australian Energy Market Operator, 2023, Table 22) Australian Energy Market Operator (AEMO). (2024). 2024 Gas Statement of Opportunities https://www.abc.net.au/news/2024-04-23/gas-industry-sponsoring-masterchef-australia-hydrogen-biomethane/103753000	1. Accelerate renewable gas development pre-2030	Likelihood	Severe	Major	Minor	Major	Severe	Likely
VH7	Transport sector	INFRASTRUCTURE: The availability of charging stations significantly impacts electric vehicle adoption. If charging infrastructure is scarce or inconveniently located, potential buyers may hesitate to switch. If there are too few charging points, potential EV owners may hesitate due to concerns about running out of power during their journeys. i.e. Range anxiety COMMUNITY ACCEPTANCE: Industries and businesses may not see sufficient benefits in transitioning to electric vehicles due to operational challenges or perceived risks. Recharging time requirements makes BEV solutions for double shifted trucks unacceptable. INVESTMENT: Establishing a robust charging network requires substantial investment. If the costs are not adequately addressed, it can hinder the expansion of charging stations, making EV adoption less attractive. POLICY: Policy incentives may be insufficient to support sales targets underpinning assumptions in the ISP COMMUNITY ACCEPTANCE: Insufficient communication and outreach about available incentives can hinder uptake. ECONOMICS: Even with incentives, the upfront cost of BEVs and FCEVs can be higher than traditional internal combustion engine vehicles. Consumers may perceive this as a barrier. Resale value versus Internal Combustion Engine (ICE) vehicles will also be a factor. ECONOMICS: Growing vehicle fleet in Victoria means new ICE vehicles will continue to be added even while BEV and PHEV sales increase.	CONSUMERS UPTAKE OF BATTERY ELECTRIC VEHICLES (BEV) AND PLUG-IN HYBRID ELECTRIC VEHICLES (PHEV) NOT HIGH ENOUGH TO ACHIEVE EMISSIONS OBJECTIVES	1. Emissions: Consumer uptake delay could hinder Victoria's progress toward achieving its decarbonisation goals. The transportation sector is a significant contributor to emissions, and without widespread electric vehicle adoption, the state may fall short of its commitments. 2. Affordability: Lost opportunity for households to save on fuel costs. Savings can be approx. $1,800-2,000 per annum depending on kms and overall petrol prices. 3. Security: Lost opportunity to increase resilience in the transport sector as continued reliance on ICE vehicles poses energy security risks as production of fossil fuel declines. 4. Social Equity: Inequitable Access to Clean Transportation: Without effective incentives, electric vehicles may remain unaffordable for certain demographics or regions. This exacerbates social and economic disparities as these groups may be disproportionately represented amongst those reliant on ICE vehicles 5. Economic Disadvantages: Delayed electric vehicle adoption can have economic repercussions. The automotive industry, charging infrastructure providers, and related businesses may miss out on growth opportunities leading to reduced job creation, missed economic benefits, and potential loss of competitiveness.	Severe	Major	Minor	Minor	Severe	Likely	Very High	To achieve net zero emissions, and the commitments in the Victorian emission reduction pledges, Victoria must adopt alternative transport technologies, like zero emissions electric and hydrogen vehicles. Includes consideration of relative cost of the new vehicle, and also depreciated or resale value. The adoption of zero-emissions vehicles in Australia is significantly lagging other countries with less than 4% of new cars being electric compared to 9% globally. In Victoria, only 6.6% of new light vehicles sold are EVs. (D'Ambrosio, 2023) Latest sales figures from the FCAI show EV sales have increased in March as a proportion of overall sales, to 9.5% in March 2024. Federal Chamber of Automotive Industries (2024). New Record for March New Vehicle Sales New Vehicle Efficiency Standard, will place a requirement on manufacturers to reduce emissions from new passenger vehicles by more than 60 per cent by 2030, and roughly halve emissions of new light commercial vehicles over the same period. The announcement also refers to $60m under the driving the nation fund to boost EV charging at Australian dealerships. Department of Infrastructure, Transport, Regional Development, Communications and the Arts. (2024). New Vehicle Efficiency Standard Introduced In 2023, the Victorian Government walked back their EV incentive program prematurely, decreasing consumer incentive to switch to EVs. Without a consistent attractive incentive, the switching cost of for lower-income households may be greater than simply retaining their petrol vehicle, leading to undershooting BEV and FCEV adaption targets. (Akhtar, 2023) There has been a 22% increase in fast and ultra-fast charger locations in Australia since 2021. Approximately 350-450 chargers are now available to the public. However, this growth rate may not be keeping pace with the surge in EV sales, which are estimated to have increased by 65% since 2021. The availability and convenience of charging stations significantly influence electric vehicle adoption, as insufficient infrastructure or inconveniently located chargers may deter potential buyers and contribute to range anxiety. (Electric Vehicle Council, n.d.)	1. Greater EV take up by 2030 -Consider higher EV sales target, and or combined vehicle target across all segments -Provide consumer incentives for EV ownership (e.g., zonal traffic charging, free municipal parking) and away from ICE ownership (e.g., increased tax 2. Implement comprehensive support measures for the development of Electric Vehicle (EV) charging facilities 3. Implement Infrastructure Victoria's recommendations to enhance public transport and support other modes of transport that do not use ICE vehicles	Consequence: Emissions Likelihood	Severe	Major	Minor	Minor	Severe	Likely
VH8	Electricity Sector	ECONOMICS: Projects require significant funding commitments. Funding constraints could arise from budget limitations, changes in government priorities, or economic downturns. Competing infrastructure projects or shifting priorities may lead to projects being deprioritised. 8 REZ developments across a +20 year timeframe may see cost increases against current projections. COMPLIANCE, APPROVALS, PROCESS: ISP shows rapid scale up in capacity from 2028 to 2040, particularly around development of offshore wind. High risk of project delays for major infrastructure projects on this scale. COMPLIANCE, APPROVALS, PROCESS: Regulatory approvals and compliance play a crucial role in infrastructure projects. Delays or rejections due to environmental concerns, land acquisition issues, or legal disputes could hinder the project or increase costs. TECHNOLOGY: Complex engineering and technical challenges may arise during project execution. COMMUNITY ACCEPTANCE: Public opposition, community protests, or disagreements among stakeholders (such as local residents, environmental groups, or indigenous communities) could lead to project delays or abandonment. SUPPLY CHAIN: Disputes with contractors, delays in procurement, or contractual disagreements could affect project implementation. ENVIRONMENT/ SUSTAINABILITY: Potential environmental impact of infrastructure on the local environment hinders project approvals and construction	MAJOR TRANSMISSION PROJECT DELAYS (MARINUS LINK, VNI WEST, V1-V8 REZS, WESTERN VIC, EASTERN VIC)	1. Emissions: Delays could postpone the reduction of greenhouse gas emissions and hinder progress toward climate goals, given its impact on the development of onshore and offshore VRE in Victoria. 2. Emissions: Delayed implementation of any single project might have a bearing on retirement of brown coal through period. 3. Affordability: Delays may impact electricity prices, supply-demand balance, and market competition. If it is delayed, it could affect market participants, energy trading, and investment decisions. 4. Reliability: Increased interconnection supports security and reliability with a greater diversity of supply sources. Delays to interconnection will impact overall reliability.	Severe	Major	Insignificant	Major	Severe	Likely	Very High	AEMO, 2023 Electricity Statement of Opportunities, (August 2023) states delays to any projects have the potential to result in periods of high risk (of delays and disruptions) throughout the 10-year horizon An average Victorian residential consumer will pay more than an additional $1,500 in energy bills over 15 years due to a two-year delay in critical transmission projects, with a four-year delay resulting in an increase of approximately $4,800. (DEECA 2023h) https://www.abc.net.au/news/2023-07-04/federal-government-launches-transmission-line-review/102559232 highlights deepening grassroots opposition to several big-ticket power lines required for the transition towards renewable energy.	1. Comprehensive and sustained public communications campaign that links all of the transition pieces together 2. Implement a comprehensive energy transition workforce investment plan 3. Improving community acceptance and supporting approvals of major energy infrastructure projects	Likelihood	Severe	Major	Major	Major	Severe	Likely
H9	Transport sector	CONSUMER INCENTIVES: Natural EV charging profile on a flat tariff likely to favour existing peaks, therefore adding significant load, and increased peaking requirement. INFRASTRUCTURE: Increase in peak usage profile due to EVs will require network augmentation and management solutions. INFRASTRUCTURE: Availability of public charging infrastructure and the variety of options (home, office, highway, car parks, etc) may impact profiles. TECHNOLOGY: Battery Sizes and Charging Speeds: EVs with larger batteries tend to require more energy during charging. As battery capacities increase, the charging profile may become peakier. Ultra-fast chargers, while convenient for long trips, can contribute to peak demand due to their high charging speeds. COMMUNITY ACCEPTANCE: Behavioural Barriers and Preferences: Factors such as perceived charger scarcity, queuing, and inconvenient locations can influence charging behaviour.	EV CHARGING PROFILE IS PEAKIER THAN ANTICIPATED IN THE ISP	1. Reliability: Energy Grid Strain: A peakier charging profile can strain the energy grid during specific hours. High demand concentrated in short time spans may lead to overloading of local transformers and substations. Grid operators may need to invest in infrastructure upgrades to accommodate the increased load, which can be costly and time-consuming. 2. Reliability: Increased Peak Demand Charges: Commercial and industrial EV charging stations often face peak demand charges based on their highest usage during specific time intervals. A peakier profile can result in higher electricity costs. Businesses and public charging providers may need to manage their charging schedules strategically to minimise peak demand charges. 3. Environmental Impact: If EVs predominantly charge during peak hours, while thermal stations still provide a firming role, this will draw more on these stations, increasing gas fired generation emissions. 4. Policy and Planning Challenges: Challenges for policymakers in providing the right incentives for consumers to charge outside peak periods 5. Social Equity: Peakier profiles may disproportionately affect certain communities or regions.	Insignificant	Insignificant	Insignificant	Severe	Severe	Possible	High	The AGL EV orchestration trial looks at different modes for orchestrating and controlling customer charging patterns, it shows control is highly effective at managing peak loads. In this report and in other presentations they have shown that a completely unconstrained charging profile does tend to peak when the rest of electricity consumption peaks. The ISP assumes a particular load profile over time. Actual load profiles may turn out to be peakier than the one assumed by AEMO in the ISP depending on control of customer charging and incentives to charge at different times of the day. https://arena.gov.au/assets/2022/09/agl-ev-orchestration-trial-lessons-learnt-report-4.pdf	1. Develop and implement tariff designs to incentivise electric vehicle (EV) charging at optimal times of the day through time-of-use pricing 2. Explore and implement smart charging technologies that dynamically adjust charging rates based on grid demand	Consequence: Reliability, security, safety	Insignificant	Insignificant	Insignificant	Severe	Severe	Possible
H10	Electricity Sector	INVESTMENT: Availability of private finance in Victoria to back projects ECONOMICS: Changes in Capital costs. For example wind costs have significantly increased in recent years SUPPLY CHAIN: Workforce availability in Victoria seen as a major constraint. SUPPLY CHAIN: Access to key supply chain components SUPPLY CHAIN: Access to land. COMPLIANCE AND APPROVALS: Increasing development lead times may delay timely build out. POLICY: Lack of clear policy post 2030 may impact build beyond that date, for example CIS scheme target 2030 capacity COMMUNITY ACCEPTANCE: Public perception, community consultations, and stakeholder engagement play a significant role. Opposition from local communities or concerns about visual impact, noise, and fishing activities can hinder project progress. ENVIRONMENT/ SUSTAINABILITY: Potential environmental impact of infrastructure on the local environment hinders project approvals and construction	DEVELOPMENT AND FUNDING RISK FOR ONSHORE VARIABLE RENEWABLE ENERGY (VRE) AND CLEAN DISPATCHABLE RESOURCES	1. Emissions: Delays or scale back in development of onshore VRE and dispatchable power will likely push back coal retirement dates, impacting emissions objectives. 2. Reliability, Security and Safety: Delays in development of clean dispatchable power and other new firming technology will have a bearing on ability to retire coal while maintaining reliability 3. Affordability: Lower VRE build will men less zero short run marginal cost energy in the system. Less clean dispatchable power will impact pricing in peak periods. 4. Social Equity: Increase in the cost of wholesale electricity may be borne disproportionately by vulnerable groups	Major	Insignificant	Insignificant	Major	Major	Likely	High	The CEC provides regular reporting on progress to meet renewable targets. https://assets.cleanenergycouncil.org.au/documents/resources/reports/clean-energy-australia/Clean-Energy-Australia-2024.pdf The CEO notes in the 2024 report that 2023 saw a slowdown in new financial commitments to utility scale generation capacity at $1.5billion, significantly down on $6.5 billion for 2022. This reflects a more complex and challenging landscape for new investment decisions, which continue to include a constrained grid, slow planning and environmental assessment processes in some jurisdictions, higher costs and tighter markets for equipment and labour. The policy environment has also been uncertain, with a long-term Renewable Energy Target which is scheduled to wind-up at the end of 2030.	1. Comprehensive and sustained public communications campaign that links all of the transition pieces together 2. Implement a comprehensive energy transition workforce investment plan 3. Continue implementation of VRET and/or CIS to support the build-out of the renewable resources in Victoria (beyond 2030) 4. Improving community acceptance and supporting approvals of major energy infrastructure projects	Likelihood	Major	Insignificant	Insignificant	Major	Major	Likely