Victoria's Zero Emission Bus Transition Plan

Cleaner, greener and smarter buses for a modern transport network

November 2024

VICTORIA State Government
Department of Transport and Planning

ACKNOWLEDGEMENTS

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Accessibility

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We proudly acknowledge Victoria's First Nations people and their ongoing strength in practising the world's oldest living culture. We acknowledge the Traditional Owners of the lands and waters on which we live and work and pay our respects to their Elders past and present.

Description of artwork

Aaron (Gunaikurnai) 'Movements Between the Five Clans' 2019, acrylic on canvas.

'The tracks are going between the five clans of the Gunaikurnai and the hands are the symbols of my spirit travelling around the campsites.'

This artwork was created through programs provided by the Torch. The Torch provides art, cultural and arts industry support to Indigenous offenders and ex-offenders in Victoria. The Torch aims to reduce the rate of re-offending by encouraging the exploration of identity and culture through art programs to define new pathways upon release.

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MINISTER'S FOREWORD TO VICTORIA'S ZERO EMISSION BUS TRANSITION PLAN

Victoria is about to conclude one of the most significant technology trials in the state's history.

Across three years we've introduced 52 zero-emission buses (ZEBs) to Victoria's extensive bus network while suppliers, operators and the Victorian Government gauged the impact and success of different powertrain technologies.

The ZEB trial is unlike anything the Victorian Government has implemented. Normally, a transition to new technology of this magnitude would occur far more gradually.

But when it comes to emissions reductions, we know the need for urgency is clear. As the fastest-growing and second-largest emitting industry sector in the state, transport is one of the keys to meeting the Victorian Government's commitment to net-zero emissions by 2045.

This plan reflects the outcomes of the ZEB trial. It documents the different experiences of bus operators, what they learnt and the lessons that will shape the future of public transport in Victoria.

It charts the next phase of the transition to ZEBs and how we will sequence the introduction of new technology according to the size, location and role of specific bus fleets.

There are symbolic and practical reasons for public transport taking a leadership role in reducing emissions.

Each year, buses move more than 135 million Victorians, connecting them with work, school, services, recreational activities and shops. Each bus takes the equivalent of 50 cars off our roads, so a well-patronised bus network is highly effective in driving down emissions.

In addition to the environmental benefits, transitioning Victoria's fleet of over 4500 buses to ZEBs delivers health benefits and the prospect of smoother, quieter journeys. Building ZEBs locally also presents opportunities to expand jobs, grow industry capability and introduce innovative technology solutions.

As Victoria's population grows to over 10 million by the middle of the century and Melbourne becomes a city the size of London, buses will be critical to servicing our transport needs. That's why since 2014, the Victorian Government has invested $550 million in new, more frequent and extended bus services right across the state.

This year's budget invests a further $30 million in improved links to new bus interchanges, improved weekend bus services, continuation of the Melton South FlexiRide, and more frequent services. This is on top of the record investments we've made in the network through Growth Area Infrastructure Contributions.

We're in the midst of a historically significant expansion of the public transport network, but we're also facing the greatest challenge of our time in averting climate change. Public transport will be a key component not just in reducing emissions, but ensuring our city retains its legendary liveability. A better bus network will make a big contribution toward meeting those goals.

This plan is the result of key players in the industry working together for a common aim. The enthusiasm, determination and goodwill exhibited have been encouraging and gives me great confidence for the future.

The ZEB Transition Plan will become the launch pad for a successful and sustainable bus network as we embark on a journey that maximises the benefits for customers, community, industry and the environment.

Gabrielle Williams MP
Minister for Public and Active Transport

OVERVIEW

As part of Victoria's drive to achieve net-zero emissions by 2045, the Victorian Government has committed to all new public transport buses purchased from 1 July 2025 being ZEBs. *Victoria's ZEB Transition Plan* sets out the pathway for delivering this commitment and making the shift to a cleaner, smarter bus fleet as part of a modern bus network that meets the needs of customers across the state.

Transport is the fastest-growing and second-largest greenhouse gas emitting industry sector in Victoria. Reducing emissions from the sector is essential to Victoria reaching net-zero emissions by 2045. Victoria is already a national leader in reducing transport emissions and the Victorian Government has set targets for zero emission light vehicles, the government fleet and public transport buses.

As part of Victoria's Climate Change Strategy, the Government has made five-year pledges setting out the actions it will take to cut emissions from different industry sectors. Under the first Transport Sector Pledge, all new public transport buses purchased from 1 July 2025 will be ZEBs. Making the transition to ZEBs aligns with *Victoria's Bus Plan*, which is building a modern, safe, reliable and sustainable bus network across the state. An important element in this network is the introduction of a cleaner, smarter bus fleet that not only reduces emissions, but also improves passenger experiences – encouraging more people to take the bus.

Transitioning Victoria's public transport fleet of more than 4,500 buses to ZEBs also opens up opportunities for Victorian manufacturers to build ZEBs and ZEB components locally or to participate in global ZEB supply chains.

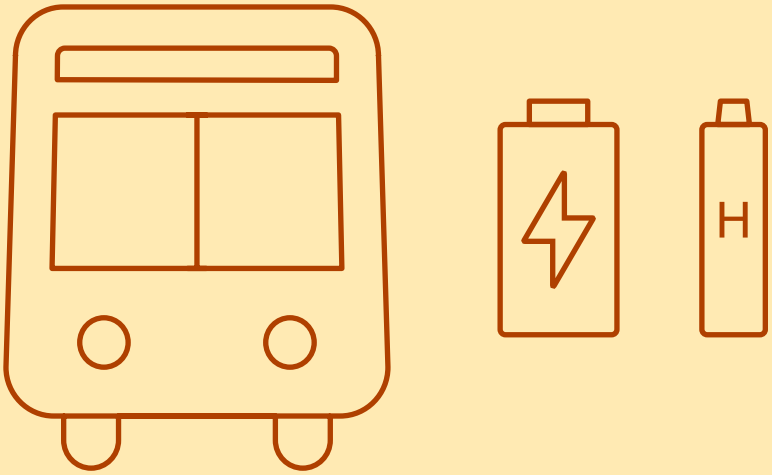
Making a transition of this scale is a challenging task. It will affect all bus service contracts in Victoria, with diesel buses being replaced with ZEBs across the network each year until the transition is complete. It will require significant investment, new ways of operating the bus fleet, upgrades to bus depots and equipment, new charging infrastructure and software systems, input from the energy sector and workforce training in new skills and capabilities. The transition also needs to deliver value for money for Victoria.

In August 2022, the Victorian Government provided $20 million for a three-year ZEB Trial that introduced 52 ZEBs into operation in Victoria across city and country bus routes. Lessons learned from the trial have informed the ZEB Transition Plan.

In August 2023, the Government released the ZEB Transition Consultation Paper, seeking the views of bus operators, the broader bus industry and interested Victorians on the transition. The Government also conducted market soundings to assess the commercial implications of the ZEB transition and met with bus operators and manufacturers to understand their preferences and capabilities in making the transition. Feedback from these consultations has helped to refine the transition approach.

The award of the Metropolitan ZEB Franchise happened in September 2024, which includes the delivery of over 600 ZEBs during the term of that franchise.

Building on these actions, *Victoria's ZEB Transition Plan* sets out how the transition will proceed in a balanced, fair and sequenced manner in partnership with the bus industry and with ongoing strong support from the Victorian Government.



What is a ZEB?

ZEBs provide a cleaner and greener way to travel on public transport. Unlike diesel buses, ZEBs don't release carbon emissions or pollutants into the air. Instead, ZEBs use electric batteries or hydrogen fuel-cell technology to power the bus. This means no internal combustion engine, no dirty exhaust emissions and no loud engine noise. ZEBs also don't need oil changes and require less overall maintenance.

Currently, ZEBs use either an on-board battery pack (charged using an external electricity source) or hydrogen (pumped into on-board tanks) to power the bus's electric motor.

TRANSPORT EMISSIONS ARE HIGH AND GROWING

Transport-related emissions have been increasing in Australia – and a growing population means even more demand for travel and more emissions. Victoria cannot meet its net-zero targets without a fundamental change in how road transport is powered. That means making a significant shift away from petrol and diesel vehicles.

Transport is the second-largest source of emissions in Victoria, accounting for about 25 per cent of the state's total emissions. While emissions are declining in most industry sectors, transport emissions are increasing. Between 2005 and 2019, emissions from the sector increased by 12 per cent (emissions decreased during the COVID period but are rebounding). Unless action is taken, this trend is forecast to continue as Victoria's growing population increases the demand for travel.

Road transport (including, cars, buses and commercial vehicles) generates almost 90 per cent of the sector's emissions. Victoria's publicly funded diesel bus fleet produces around 250,000 tonnes of CO_2 equivalent emissions annually, which is the same as emissions from about 100,000 cars.

The Victorian Government is taking a range of actions to promote a shift to more sustainable forms of transport and build Victoria's resilience to a changing climate. These include better integrated land use and transport planning, new investment in the state's public transport system, more walking and cycling infrastructure, and initiatives to move more freight by rail. While these measures are important, achieving a complete decarbonisation of the state's road network is critical to reducing emissions from the transport sector and meeting Victoria's net-zero targets.

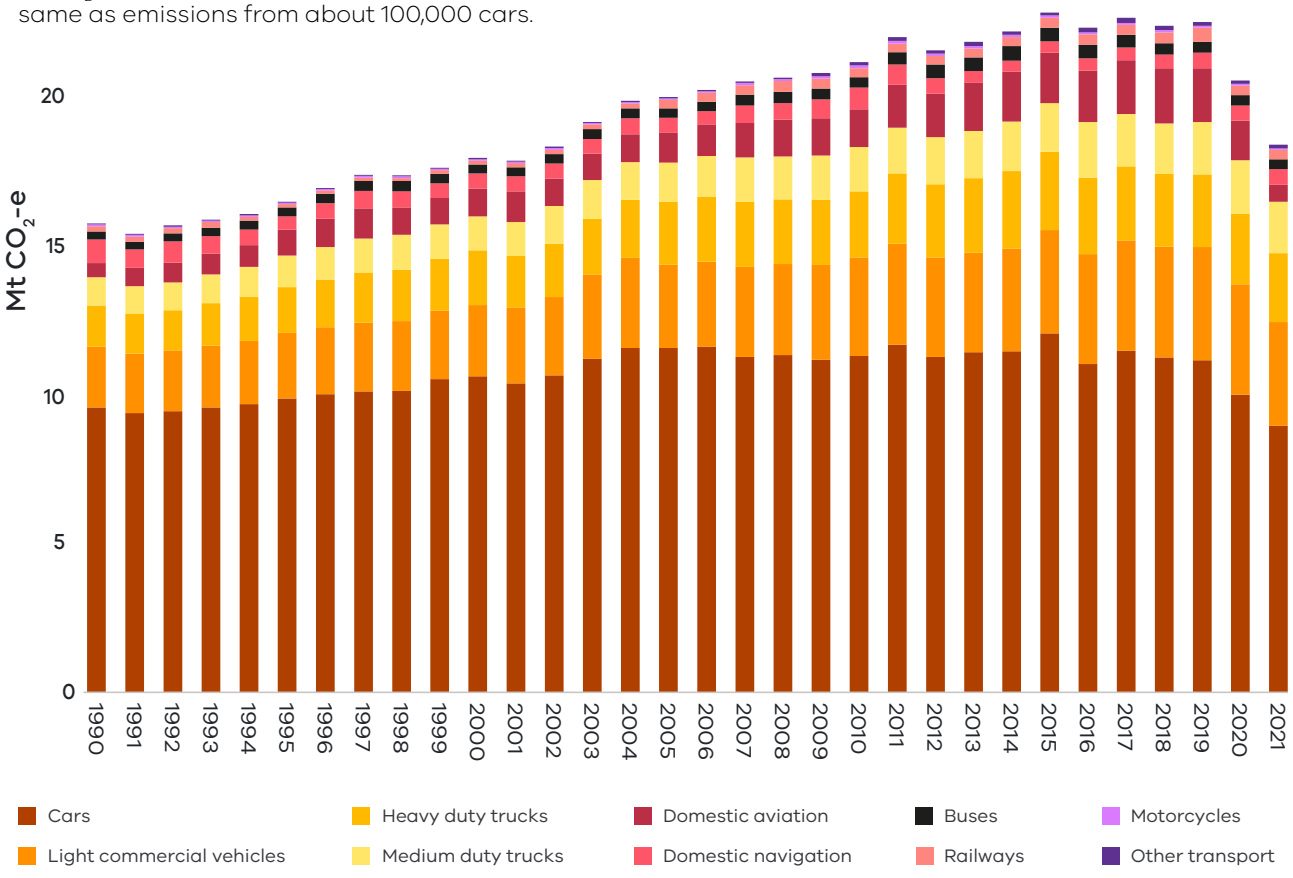


Figure 1. Emissions by transport sub-categories – Victoria, 1990 to 2021
Source: State and Territory Greenhouse Gas Inventories 2021 (DCCEEW, 2023e))

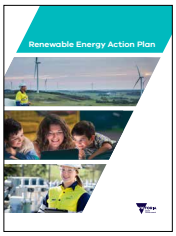

KEMPOWER
MONASH IS
SMOKE-FREE

LEADERSHIP AND ACTION ON CLIMATE CHANGE

The Victorian Government is taking strong action to reach net zero emissions by 2045, support communities, businesses and institutions to better prepare for a changing climate and enable Victorians to take up and benefit from the exciting opportunities created by the global shift to new climate-friendly technologies.

Victoria's **Climate Change Strategy** sets out a pathway to achieving net-zero emissions and a climate resilient state by 2045. The strategy includes actions to transition the state to a clean energy future, invest in innovative technologies, safeguard the role of the natural environment in reducing emissions and support businesses, farmers and communities to thrive in a net-zero emissions future.

Building Victoria's Climate Resilience identifies what Victoria is doing to adapt and build resilience to a changing climate. Guided by the latest science, Victoria's approach focuses on understanding the risks from climate change, supporting vulnerable people and assets, and protecting essential systems and services.



The **Renewable Energy Action Plan** outlines how a modern energy future will provide renewable, affordable and reliable energy for all Victorians while also generating investment and new jobs across the state. The plan aims to put Victoria at the forefront of the renewable energy transition, delivering significant economic, social and environmental benefits.

To help reach emissions targets, the Victorian Government has made five-year pledges that outline the actions it will take to cut emissions from different industry sectors. The first **Transport Sector Pledge set** a 50% zero emissions vehicles (ZEVs) target for all new light vehicle sales in Victoria by 2030 and a target of 100% of bus purchases for use on the public transport network being ZEBs from 1 July 2025.

Victoria's ZEV Roadmap includes actions to accelerate the transition to electric vehicles, including investment in charging infrastructure, direct subsidies, research and innovation. The Roadmap reinforces the Victorian Government's intention to 'lead the market' by setting targets for replacing the Government's car fleet with ZEVs and making the shift to ZEBs on the public transport network.


1924
Pakenham 925
100% ELECTRIC
ZERO EMISSIONS BUS
Dependable, friendly and sustainable bus services
Ventura
PT

WHY IS VICTORIA TRANSITIONING TO ZEBS?

Transforming Victoria's bus fleet to zero emissions will help to curb rising transport emissions, reduce the pollution associated with traditional diesel buses and encourage more people to use bus services rather than cars. Shifting to ZEBs also creates opportunities for local businesses and industries.

The world is rapidly moving away from fossil fuel-based transport fleets to more sustainable transport technologies. As cities and countries put plans into action to transition their public transport networks to zero emission vehicles, it is becoming easier to see and articulate the significant benefits from making this shift.

ZEBs deliver health benefits

Around 3,000 Australian deaths each year can be attributed to urban air pollution. Diesel vehicles are significant sources of air pollution in urban areas. Diesel exhaust contains pollutants that can aggravate existing respiratory illnesses and increase the risk of cardiovascular and respiratory disease. Shifting bus fleets to ZEBs improves air quality around depot sites, along bus routes and at busy intersections, making an important contribution to more liveable, healthy and sustainable cities and communities.

ZEBs provide a smoother and quieter ride

ZEBs offer a smoother ride due to improved vehicle ergonomics and electric propulsion technology, and lower levels of noise and vibration. This means that passengers enjoy a better experience when travelling by bus. Bus drivers also have a better working experience. During the ZEB Trial, drivers reported that less vibration and noise than a diesel engine leaves them feeling better at the end of a shift. ZEBs also reduce noise pollution where bus routes run through suburban streets and local shopping centres.

ZEBs are less costly to run and maintain

While there are currently higher upfront costs to purchase ZEBs, operating and maintenance costs are lower. Indications from Victoria's ZEB Trial – and from ZEB trials and operations worldwide – are that energy consumption costs for a standard Battery Electric Bus are almost two-thirds lower than a diesel equivalent. ZEBs also have simplified drive trains, with less mechanical moving parts compared to the diesel equivalents. This means lower maintenance costs and less complex maintenance requirements.

There are opportunities for local businesses and industry

The introduction of ZEBs and continuing advances in clean propulsion technologies can spur investment and create jobs in existing and new industries. There are potentially significant opportunities for local Victorian businesses in manufacturing ZEBs and ZEB components, and constructing and fitting out ZEB depots. As the international road vehicle market shifts away from internal combustion engine technologies, local enterprises may benefit from participating in global ZEB supply chains. There may also be opportunities to leverage Victoria's emerging leadership in battery and clean energy technology research, innovation and development.

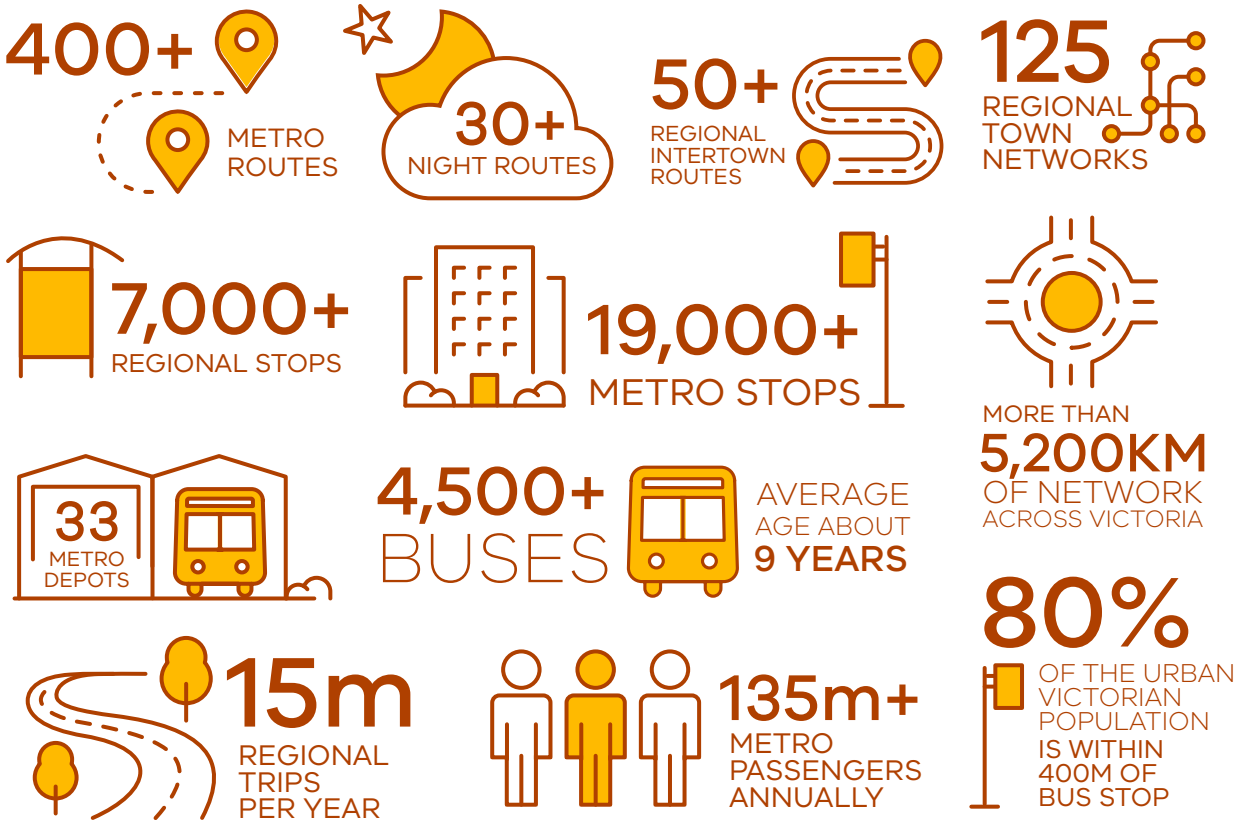
VICTORIA'S BUS NETWORK

The ZEB transition is occurring in a complex operating environment with a diversity of services, routes, operators, investors and commercial arrangements. This means that a 'one size fits all' approach will not work. A successful transition approach needs to respond to different operating models, fleet sizes, depot locations and sizes, and the nature of the services delivered.

Buses are a vital part of Victoria's public transport system, currently supporting over 135 million passenger trips each year across the state. Buses provide a range of services – from school buses and local neighbourhood services to services that link destinations across Melbourne and over 50 regional towns and cities – and are closely integrated with the metropolitan and regional rail system.

Buses provide accessible travel for schoolchildren, older people and people with limited access to other transport modes, such as a car. For many Victorians, buses are the nearest and most practical public transport choice, with 19,000 bus stops across metropolitan Melbourne and 7,000 bus stops across the regional bus network.

November 2024



▲ Figure 2. Snapshot of Victoria's bus services

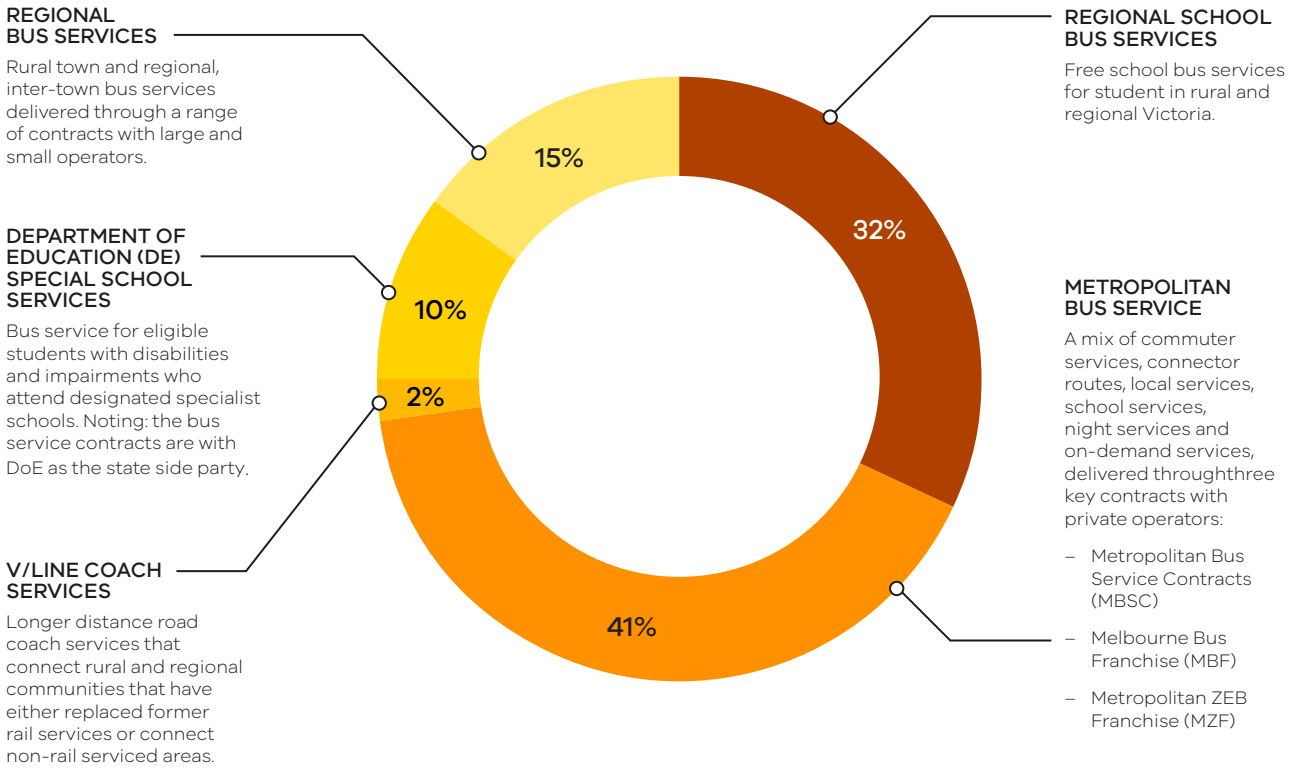
Victoria's bus operators

Across Victoria, bus operators vary in size. Operators with a larger fleet typically operate services from multiple depots. More than 80% of contracted metropolitan and regional bus services are operated by the 20 largest operator groups. Operators with smaller fleets are based mainly in regional Victoria, operate school bus services and often use open space on a private property as the base for their operations (instead of a depot or a commercial property).

Some operators also run charter, rail replacement or other services in addition to their contracted services.

The circumstances of all of these operators has been considered in developing the ZEB Transition Plan. Ongoing partnership and cooperation between the Victorian Government and all bus operators is essential to a successful ZEB transition.

Victoria's public transport bus services are delivered under various DTP contractual arrangements, summarised in the figure below.



Note: Percentages are an approximate portion of fleet across Victoria.

Figure 3. Public transport bus services in Victoria

ZEBS AND A MODERN BUS NETWORK

The ZEB transition will take place at the same time as a major reform of the bus network being delivered through *Victoria's Bus Plan*. As more and more ZEBs join the fleet, they will need to come into operation in ways that support *Victoria's Bus Plan* and contribute to a modern, smarter and more environmentally sustainable bus network.

Victoria's Bus Plan aims to achieve six reform objectives, shown below.

Under the plan, the bus network is being reconfigured to achieve these objectives, including the creation of new route categories designed to make journeys faster, more frequent and more reliable.

The ZEB transition will support and integrate with this network reform. As they transition to ZEBs, bus operators will need to make sure they can provide the 'right buses for the right routes' as part of the future network.

While the combination of network reform and the ZEB transition poses challenges, it also presents opportunities for the Victorian Government and the bus industry to explore new ways to deliver services and to harness technology to help transform the bus network.

Further information about *Victoria's Bus Plan* is at engage.vic.gov.au/busreform.

Figure 4. Victoria's Bus Plan objectives

OBJECTIVES OF THE ZEB TRANSITION

Six objectives are guiding the mplementation of Victoria's ZEB transition. These objectives align with *Victoria's Bus Plan* and aim to maximise the environmental, health, community and industry benefits of making the shift to ZEBs.

Figure 5. ZEB transition objectives


Zero Emissions
3013
100% ELECTRIC BUS
Zero Emissions
VOLGREN
PT
PT
B509 KB
IMPERIAL

THE ZEB TRANSITION: MAKING IT HAPPEN

Transitioning Victoria's public transport bus fleet is a challenging task. A sequenced approach will minimise disruption to the bus industry, maintain the continuity of bus services and make sure that the components of a successful transition are integrated seamlessly into the state's transport networks.

The ZEB transition will affect all bus service contracts in Victoria. While current bus contracts vary, they all require diesel fleet replacements as older buses are retired. Under current contracts, approximately 220 buses (largely evenly split between high and low floor fleet) are replaced across the network each year, with annual replacements ranging from 30 to 40 for larger contracts to no or minimal replacements for smaller contracts.

The transition to ZEBs is about more than replacing the existing fleet. The smooth operation of a statewide ZEB fleet requires investment in depots, charging equipment, energy grid upgrades, software systems and workforce skills. It also requires updated standards and specifications to ensure ZEBs operate safely and effectively. Operational changes may also be needed to integrate ZEBs into existing routes and timetables, and with the future bus network introduced under *Victoria's Bus Plan*.

A sequenced, orderly fleet transition

The scale of Victoria's bus network, the varying age profiles of different bus fleets and the need to maintain bus services for customers means it is not feasible to transition all services to ZEBs at the same time. Transition will be sequenced in tranches – in portions or instalments.

A tranched approach will ensure that diesel buses are replaced and depots converted in an efficient, timely way to achieve a full transition to ZEB operations across the network. Tranching the ZEB transition also allows timely adoption and consideration of technology shifts, improvements in battery chemistry and innovations in ZEB design to be captured in the transition.

The ZEB transition has been planned to be fair to operators and to minimise disruption to the bus network. Reflecting advice from the bus industry, allowances have been made for those parts of the industry that will need more time to make the shift to ZEBs.

Starting early

The ZEB transition has already commenced, with the transition of 688 diesel buses to ZEBs (approximately 15 percent of Victoria's fleet) already underway.

1. ZEB Trials and Existing Metropolitan Bus Franchise

The Victorian Government invested $20 million to conduct three-year statewide trials of ZEBs, commencing in August 2022. Six Victorian bus operators were selected to trial 52 ZEBs on existing routes across metropolitan and regional bus networks. The trial means that 50 Battery Electric Buses (BEBs) and two Hydrogen Fuel Cell Buses (HFCBs) are already operating on the Victorian bus network.

Lessons from the trials are supporting the full ZEB transition, providing on-the ground practical information about depot charging needs and capacity, infrastructure and energy requirements, environmental outcomes, customer expectations and commercial arrangements.

Under the current Melbourne Bus Franchise (MBF), 36 ZEBs have been funded and are being progressively introduced ahead of the transition plan commencing in 2025.

2. New Metropolitan ZEB Franchises

One third of metropolitan public transport buses (approximately 600 buses, over 10 percent of the Victorian Public Transport bus fleet) will transition to ZEBs between 2025 and 2035 under five new Metropolitan ZEB Franchises (MZFs) as part of *Victoria's Bus Plan*. Operators of the new franchises will lead the procurement of ZEBs and associated depot and infrastructure upgrades in consultation with DTP and complete the transition to full ZEB operations by the end of the franchise terms in June 2035.

The MZF procurement process is providing important learnings on the best approach to making the ZEB transition across other types of bus service contracts.

Getting ahead of the transition

Across Victoria, a number of bus operators are already making the shift to ZEBs. Some of these operators have been part of the ZEB Trial; others have moved independently to incorporate ZEBs into their operations.

ComfortDelGro Corporation (CDC) purchased its first hybrid-electric bus in 2019 and now operates 50 hybrid buses in Victoria. CDC has reported that, over four years, its Victorian hybrid fleet reduced fuel use by more than 1,273,000 litres and lowered CO_2 emissions by 3,428 tonnes. As part of the ZEB Trial, CDC worked with partners ENGIE, Volvo, Volgren, Monash University and TSA Advisory to locally manufacture and test eight BEBs on routes in Melbourne's south east. CDC has also installed Australia's first offsite bus charging station at the Monash University bus interchange and also upgraded infrastructure at its Oakleigh depot.

Metropolitan bus operator Kinetic is progressively introducing 36 BEBs to Melbourne's public transport network. The BEBs are built locally and operate from two depots in Sunshine West and Heatherton. Kinetic has reported that its BEBs are performing well, with some buses exceeding the 300km range per charge.

Ventura, the largest bus operator in Victoria, has converted its Ivanhoe depot to fully electric operations, supporting 27 BEBs covering routes across Melbourne's northern suburbs. The depot conversion included installation of a new transformer on site and upgrading the grid connection to support fast chargers.

Sequenced rollout from 2025

The ZEB transition will generally follow the existing diesel bus replacement program, however, reflecting advice from the bus industry and operators, and the availability of ZEB fleet types, allowances have been made for those parts of the industry early in the transition that will need more time to make the shift to ZEBs.

This means from 1 July 2025, all orders for new public transport buses must be zero emission (unless an allowance has been made as described below).

Diesel buses may continue to be ordered up to 30 June 2025, giving operators time to prepare for the transition and maintain service continuity.

Over the next four years an additional 250 low floor buses will be replaced by ZEBs (Tranche 3) to add to the 688 already funded. This will transition over 20 percent of Victoria's Public Transport Bus fleet, or 1 in 5 buses will be ZEBs by the end of Tranche 3.

Approach by contract (excluding MZF)

MBF

The MBF is one contract covering about 540 buses, or approximately 30 per cent of the metropolitan bus services. The existing fleet replacement program will be followed for the MBF.

Metropolitan bus service contracts

Seven Metropolitan Bus Service Contracts (MBSC) covering four operators (~40 per cent Metro Services) are due to expire in June 2028. While some ZEBs are expected to be introduced ahead of the next contract, the life of existing diesel buses will be extended by up to five years for the majority of the MBSC fleet. Replacement of the majority of ZEBs are expected to be undertaken as part of the new contract term.

Large regional bus services

The largest Regional Bus Services Contracts cover the major Victorian regional centres and towns: Geelong, Bendigo, Ballarat, Latrobe Valley, Mildura, Warrnambool, Shepparton and Bacchus Marsh (~60 per cent Regional Town Services). The existing fleet replacement program will be followed for these contracts.

Small regional bus services

Reflecting operator feedback, the requirement to replace diesel buses will be extended by up to five years for these smaller contracts (other than regional centres and towns referenced in the previous paragraph) through life extensions of existing diesel buses, giving them more time to prepare for and make the ZEB transition as advocated for during the ZEB Consultations. Replacement of existing diesel buses with ZEBs as they fall due for retirement is expected to commence from 2030.

Regional school buses

Regional School Bus Services Contracts cover about 1,450 buses, many of these are operated by smaller operators with one or two buses per contract. As for smaller regional bus operators, based on operator feedback these services will be permitted to extend the operational life of diesel buses by up to five years. Replacement of retiring school buses with ZEBs is expected from 2030 onwards.

V/Line coach services

Around 100 high-floor buses are used to deliver V/Line long-distance services in regional Victoria and interstate. As there is currently no feasible ZEB option for this fleet type, diesel/hybrid bus replacements will continue to be used for V/Line coach services for up to five years. During this time, the Victorian Government will work with local manufacturers to develop a ZEB solution for long-distance coach services. The V/Line fleet's transition to ZEBs will commence when a feasible solution becomes available.

Department of Education (DE) Buses

The DE provides transport for specialist schools. The DE fleet is bespoke, and its role is to provide transport services for eligible students to and from special needs schools. The fleet is diverse, ranging from full size buses to minibuses many with specialised Disability Discrimination Act (DDA)-compliant access and facilities. ZEB transition solutions for this fleet are scarce but emerging, the engagement and negotiations process is expected to be similar as for that proposed for DTP Regional School buses but will be managed by DE.

Larger operator groups go first

Across all Victorian bus service contracts, ZEB replacements will start with the largest bus operator groups with multiple depots. These groups have the capability and scale to more readily undertake the transition; however, they will require significant investment in depot infrastructure and operational changes, particularly in managing mixed diesel and ZEB operations for a period of time.

DTP will work directly with individual operator groups to determine the appropriate commercial and practical arrangements for making the transition to ZEBs. ZEB replacements across these larger operator groups are expected to be implemented one depot at a time, enabling the operator's diesel fleet to be cascaded to other depots that are not yet due for conversion and minimising disruption to services.

A more streamlined approach will be adopted for smaller operators, with DTP working with them and/or their representatives such as Bus Association of Victoria to facilitate the transition as appropriate.

DTP will continue to provide guidance for operators transition planning through direct engagement and the ZEB website: Zero Emissions Bus Trial | vic.gov.au (www.vic.gov.au) which provides broad guidance and resources for bus operators. Guidance will be progressively developed to support operator delivery of the ZEB Transition, and focus on depot design, charging infrastructure and operational considerations.

Choice of ZEB technology

Two technology options are expected to support the ZEB transition in Victoria.

BEBs have an onboard battery pack that is charged using an external electricity source. BEBs are charged at a depot or charging station using the existing electricity infrastructure network. BEBs are commercially viable and proven, and several manufacturers have market-ready products and customisation options. BEBs are well suited to urban routes in Melbourne and larger regional cities and towns.

HFCBs refuel using hydrogen stored at a depot, which is pumped into a tank on board the bus. The hydrogen is used by a fuel cell stack to charge a battery that powers the electric motor. This technology is proven but there are limited products in the market and the production of the hydrogen fuel in Australia is in the early stages of technical development. HFCBs can have greater range than BEBs, are lighter in weight, can have faster refuelling times and can travel longer distances. These attributes mean they are potentially better suited to long-distance bus routes (such as regional coach services).

While BEB technology is currently more widely used, HFCBs may become more viable as the infrastructure to produce, distribute and store hydrogen matures. Other technologies are also likely to emerge and evolve in the years ahead.

Victoria's ZEB Transition Plan does not mandate any particular technology option. It is up to operators to determine the best option for the services they are contracted to provide. However, following feedback from operators, the Victorian Government expects BEBs to support the initial introduction of ZEBs, particularly for metropolitan services.

The benefits of the sequenced approach to ZEB transition

- Causes the least disruption across Victoria's bus industry and bus network
- Tailors the transition to align with the capabilities and readiness of each group of bus operators which reflects consultation feedback
- Provides additional time for smaller operators to prepare for transition, consistent with industry advice
- Provides lessons that can be applied as the transition proceeds
- Allows depot and infrastructure upgrades to also be sequenced, minimising impacts to services
- Maintains an adequate order pipeline in the early years of the transition to help secure the long-term viability of local bus manufacturing jobs and capabilities
- Gives time for a local ZEB market to mature and for solutions to emerge that are appropriate to Victorian conditions.

Depots and supporting infrastructure

A successful ZEB transition will require new investment in depots and supporting infrastructure and systems. The extent of investment needed by each bus operator will vary significantly, with some requiring substantial financial commitment and considerable time for planning, design and implementation, while others may require only limited investment and a shorter timeframe.

Depot upgrades

Existing bus depots across Victoria range from large metropolitan depots that house more than 100 buses to smaller depots and private properties and garages used to store buses. Almost all of these facilities will need upgrading to accommodate ZEBs.

The nature and scale of upgrades will depend upon the size and location of the depot, space at the site, available electricity connections and ownership of the site. Depending upon an operator's circumstances, upgrades could range from the installation of minimal charging and safety equipment through to major electrical upgrades, workshop re-tooling or the construction of a new depot. Diesel assets will also need to be decommissioned.

The timing of upgrades is also an important consideration, particularly where the depot is required for continued diesel operations alongside the transition to ZEBs. Operators may opt for full depot upgrades (potentially using alternate depot sites to maintain continuity of operations) or hybrid upgrades (where different sections of the depot are upgraded incrementally).

It is up to operators to propose an approach that best suits their requirements, and then request approval from DTP to proceed. The Government's preference is that where an operator group holds multiple contracts across more than one depot, ZEB replacements are aggregated to a single depot that is fully transitioned before progressing to the next depot.

DTP will work with operators to plan for and sequence the depot conversion process to minimise disruption to bus services.

Fuelling the future

Hydrogen has the potential to be a game-changer in providing zero emissions transport. In particular, hydrogen fuel cell electric vehicles are emerging as a technology that could be deployed to meet a range of transport and mobility needs.

The Victorian Renewable Hydrogen Industry Development Plan is a blueprint for how the Victorian Government is leading and supporting the development of a thriving renewable hydrogen industry. A core focus for the plan is advancing renewable hydrogen's potential as a clean, safe and reliable fuel source that could power Victoria's heavy transport and freight sectors. This includes exploring opportunities to create a strong and stable local supply of renewable hydrogen as a substitute for natural gas, petrol or diesel fuels.

Charging equipment

Charging is expected to occur predominantly at depots. Plug-in charging – which consists of plugs and sockets that are manually connected and disconnected – is the most commonly used and cheapest option currently available. Pantograph charging typically uses an articulated arm on the BEB or at the charge point that automatically extends to charge the bus.

Refuelling with hydrogen is similar to refuelling diesel vehicles. Compressed hydrogen fuel is stored in a tank at a depot and transferred to the bus's onboard tank using a suitable high-pressure pump/compressor.

Over time, different charging technologies and systems are likely to evolve. While it is up to operators to select a charging system that meets their needs, the Government will set minimum specifications for charging equipment and associated technology to ensure interoperability of equipment across operators, fleet types and depots.

Software and smart solutions

The introduction of BEBs places an increased importance on the use of software and digital systems to manage and operate bus fleets and related data, particularly at larger depots. These systems will support the efficient management of charging equipment, batteries, energy use and depot operations.

The increased use of digital systems also creates requirements for data formatting, sharing and storage, and cyber security specifications and protocols. The Government will set standards for ZEB technology to ensure the compatibility and interoperability of these systems, and the data they produce and manage.

Energy grid connections and upgrades

Critical to the introduction of BEBs is a sufficient and reliable electricity supply to meet the fleet's charging requirements. Some bus operators may be able to meet their needs using existing electricity connections; others may require an upgrade to the off-site energy grid.

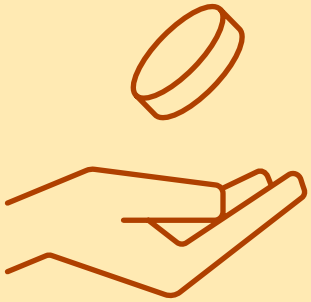
DTP will work with operators to help them determine the best solution for their depots and fleets. DTP will also work with energy providers to ensure the grid can support the charging needs of the entire public transport fleet of ZEBs when the transition is complete.

ZEBs will be connecting to an energy network that is undergoing significant transition to green energy. Over time, the energy charging the ZEB fleet will come increasingly from green energy sources, further enhancing the environmental benefits delivered by the ZEB transition.

Value for money for Victoria

In making the transition to ZEBs, any new contractual arrangements (or amendments to existing contracts) will need to support the operation of efficient bus services across Victoria and provide value for the state's investment.

Operators will be required to demonstrate value in areas such as following a minimally disruptive program of depot upgrades, adhering to standards and specifications, adopting an optimal pricing approach and realising operational savings and network efficiencies.



New standards and specifications

The Victorian Government has a key role to play in setting standards and specifications for ZEBs and ZEB infrastructure. This will ensure interoperability between ZEB assets (including the BEB fleet, batteries and chargers) while retaining the flexibility to accommodate technology improvements and respond to an evolving modern bus network. Consistency in standards and specifications will also make it easier to establish a local ZEB manufacturing industry and train the local ZEB workforce.

DTP will work with the industry and Safer Transport Victoria to continuously update safety and design standards and specifications. In particular, the Government will provide:

- A BEB vehicle specification that meets operational requirements and supports broader ZEB objectives (including local content requirements)
- Minimum specifications for charging equipment and associated technology, including interoperability requirements, and data sharing and access
- Guidance for depot upgrades, grid/charging capacity and charger specifications (similar to those provided in the MZF competitive tender).

Bus operators will be required to comply with these standards and specifications as part of their contracts.


CHARGER STATION 6
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TRITIUM

OPPORTUNITIES FOR VICTORIAN INDUSTRY

The prospect of building ZEBs – and ZEB components, equipment and infrastructure – is a significant opportunity for local industry. As part of *Victoria's ZEB Transition Plan*, the Victorian Government is prioritising the development and growth of a Victorian ZEB manufacturing industry, as well as actively encouraging investment in a highly skilled local ZEB workforce.

The scale of the ZEB transition creates scope to consider new opportunities to manufacture a broader range of ZEBs in Victoria and participate in associated manufacturing supply chains.

Growing the local ZEB industry

Local content requirements

Victoria's Local Jobs First Policy will apply to the ZEB transition. The Government will work with industry to ensure it can meet the 62 per cent requirement including activities that support supply chain research and development, access to global best practice, technology transfer and career pathways, apprenticeships and workforce skills development.

This will ensure that small and medium enterprises have an opportunity to compete for contracts. DTP will work with the bus manufacturing industry and other government agencies, both local and interstate, to maximise any benefits the Local Jobs First policy can provide.

Building industry confidence and capability

A key enabler of local industry development is certainty of orders for ZEBs. The Victorian Government is supporting industry confidence and growth in manufacturing capability by:

- Providing a clear indication of Victoria's forward ZEB fleet replacement pipeline
- Simplifying ZEB specifications to enable aggregated bus procurement, giving longer-term certainty to manufacturers and stimulating price reductions

The Government is exploring opportunities to further develop a local bus manufacturing industry by:

- Preparing a strategy to encourage local manufacture or assembly of key ZEB components
- Targeting core supply chain components, potentially including direct investment in equipment and facilities or incentives for the manufacture of components such as batteries and chargers
- Investigating alternative price mechanisms to drive competition and leverage better value from new bus purchases by operators.

Building a skilled local ZEB workforce

A skilled workforce is critical to a successful ZEB transition.

People working directly with ZEBs will need training in a range of skills. Operational staff will require ZEB vehicle and charging equipment training; drivers and yard staff will need vehicle familiarity courses; and specialist depot technicians will require technical training in ZEB maintenance and repair of high voltage systems and components. Training on new operational systems and software will also be required. While it is up to bus operators to train their staff, the Victorian Government will work with operators and training providers to ensure that appropriate education, training and upskilling is available to ensure the local workforce is properly trained and accredited to operate and maintain ZEBs.

A range of advanced skills will also be needed to build local capabilities in bus manufacturing and the development of battery and clean technologies. The Victorian Government will work closely with industry, universities and training providers to encourage young people to take up careers in ZEB manufacturing. The Victorian Government will work with other state and territory governments to advocate for Australia-wide consistency in training and certification of ZEB-related and clean technology skills.

The Local Jobs First Policy includes the Major Project Skills Guarantee (MPSG), which requires a percentage of total hours worked on construction projects to be undertaken by apprentices, trainees and cadets. The MPSG will apply to the ZEB transition.

Training the next generation of ZEB workers

The Victorian Government has invested $2 million in a pilot program at Bendigo Kangan Institute that is training bus diesel mechanics to work on ZEBs and other zero emission vehicles.

Led by the Australian Manufacturing Workers Union (AMWU) in collaboration with four major bus companies, the program is addressing two critical ZEB skills gaps: the need for technical staff (such as diesel mechanics and auto electricians) and non-technical staff (such as refuelers and yard hands). Training is provided at Kangan Institute's Automotive Centre of Excellence at Docklands in Melbourne.

Once the pilot program is completed, it will be made available to all Victorian bus operators and tailored to apprentices – giving young Victorians the opportunity to gain skills in rapidly growing new trades and to be part of the shift to a clean economy.


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TRY
DOVE MEN + CARE
EMERGENCY EXIT
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TIMELINE AND NEXT STEPS

Implementing the ZEB Transition Plan requires a series of actions to ensure appropriate funding, commercial and operational arrangements are in place to support bus operators make the shift to ZEBs.

Immediate transition timelines and steps are show in the figure below.

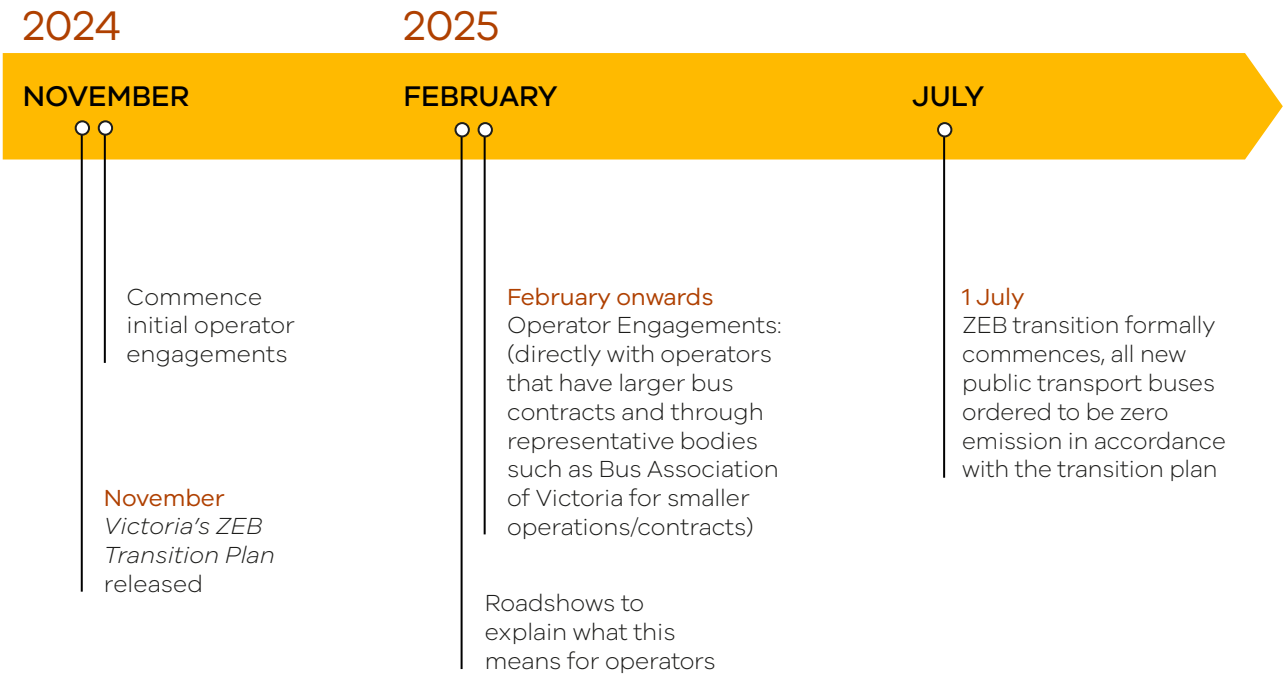

Figure 6. Timelines


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