M O V I N G  T O  Z E R O

A U T H O R S

R A C H E L  L Y N S K E Y
S I M O N  G R A H A M
M I C H A E L  L I
P E T R A  S T O C K
ACKNOWLEDGMENT OF SUPPORT

ClimateWorks Australia thanks the experts and key stakeholders who have provided input to and review of this report. We also acknowledge the contribution of Robert Anderson whose background desktop research underpins this report.

ABOUT CLIMATEWORKS AUSTRALIA

ClimateWorks Australia bridges the gap between research and action to achieve the system-level transitions required to reach net zero emissions across Australia, Southeast Asia and the Pacific. We act as trusted advisers, specialising in the development and implementation of zero-emissions pathways. Co-founded by The Myer Foundation and Monash University in 2009, ClimateWorks is a non-profit working within the Monash Sustainable Development Institute.
Executive summary

MOVING TO ZERO

Transport is the fastest growing and third largest source of emissions in Australia, behind electricity and stationary energy sectors. Australia’s road vehicle fleet is one of the most energy- and emissions-intensive in the world; the nation’s per capita aviation emissions are the world’s highest. An opportunity exists for Australia to turn these trends around and become a global leader in zero-emissions transport.

The strategies to transform Australia’s transport networks are known, with many ready to be implemented this decade. Widespread, rapid adoption of well-established solutions, along with mature and demonstrated technologies, can achieve much of what is needed this decade. Substantial investment in research, development and commercialisation can close the gap to zero emissions across the transport sector by 2050.

This report is the first comprehensive guide to how Australia can transition to zero-emissions transport. It explains where the transport sector is at today, and where the whole transport system needs to get to in order to support emissions reductions and keep global warming well below 2 degrees Celsius. It distills an analysis of over 300 reports, research papers, news articles and policy documents, collated by ClimateWorks Australia over nine months, into twelve recommendations for the transport sector to move towards zero emissions. These recommendations will be familiar to the transport sector, with the review affirming that known and established opportunities can shift Australia towards zero-emissions transport.
The recommendations cover both rapid implementation of established opportunities and actions to prepare Australia for rollout of emerging opportunities:

+ Across road, rail, maritime and aviation transport modes
+ For both passenger and freight transport
+ Covering technology, policy, standards and planning.

The transport sector is a complex system, covering multiple sectors, and servicing diverse needs across Australia’s entire economy. Its stakeholders range from government decision-makers all the way through to individual users. By bringing together opportunities for a zero-emissions transport sector in the one place, this report highlights both the commonalities and idiosyncrasies of the passenger, freight, road, rail, aviation and shipping sub-sectors. ClimateWorks recommends government, business and research institutions come together to advance policy, research and actions listed below. Many of these recommendations are already being implemented and merely require greater focus and investment. Some, however, represent innovations in Australia and thus require relevant stakeholders to establish new work programs. By collaborating to advance these twelve recommendations, the sector can set Australia on the path to a zero-emissions transport future.
RECOMMENDATIONS

ALIGN STRATEGIES, PLANNING AND FRAMEWORKS WITH ZERO-EMISSIONS TRANSPORT NETWORKS

+ Develop a shared vision of a desired zero-emissions transport system to support planning and delivery of transport infrastructure and services. This could include the development of future scenarios and the facilitation of collaborative cross-sector forums. A coordinated vision for future zero-emissions transport systems would help ensure a smooth and timely transition for the sector.

+ Align government and business transport strategies to zero emissions before 2050 for both direct transport operations and broader transport systems. This would include passenger transport operators (such as public transport operators and airlines) and freight businesses. Aligning with zero emissions at the strategic level would support downstream implementation and actions in line with broader net zero and sustainable development objectives.

+ Prioritise net zero emissions in strategic and statutory planning processes for cities, settlements, transport systems, infrastructure, and service provision. This could include minimum electric vehicle charging station requirements in statutory planning for new building developments. Incorporating net zero into specific planning mechanisms provides a regulatory driver and supporting tools to implement emissions reduction solutions.

+ Assess and manage emissions impacts of emerging and disruptive transport technologies by developing guidance, policies and regulations for federal, state and local government. This would help prepare the transport sector for emerging and disruptive technologies such as autonomous vehicles while ensuring new technologies align with zero-emissions strategies.

SHIFT TRANSPORT NETWORKS TO SUPPORT MORE EFFICIENT AND SHARED MOBILITY MODE CHOICES, THROUGH INFRASTRUCTURE, SERVICES AND PRICING MECHANISMS

+ Shift private vehicle trips to public, active and shared transport options, and shift freight from road to rail through improved service provision, subsidies, funding options and other measures. A more explicit focus on mode shift in planning and delivery of transport infrastructure and services would support more efficient, zero-emissions movement of people and goods.

+ Coordination both between and within freight stakeholders to reduce emissions. This could include coordination between passenger and freight operators to optimise use of train lines, or across modes for intermodal hubs such as ports to shift to more efficient trips.

IMPROVE VEHICLES TO RUN AT ZERO EMISSIONS

+ Review financial incentives and pricing mechanisms, such as subsidies and road use pricing, to support uptake of zero-emissions passenger and freight vehicles.

+ Continue development and implementation of vehicle emissions standards in line with international best practice, to support uptake of zero-emissions passenger and freight vehicles.

+ Build on and develop zero-emissions fleet strategies for government and corporate vehicle fleets, including electric cars and public transport. Leadership by government and corporate fleet managers in transitioning to electric fleets powered with renewable energy, complemented by investment in charging infrastructure, would enable broader uptake of electric vehicles by the community.
Support research, commercialisation and development of standards for zero-emissions, renewably-fuelled vehicles for freight, shipping and aviation. Ensuring zero-emissions vehicles are developed and rolled out where viable, supported by development of appropriate environmental and safety standards, would ensure the sector is equipped for rapid uptake of these technologies in the future.

Plan for and manage integration of electric vehicles with Australia’s electricity networks, building on existing collaborations. This would help ensure energy networks are prepared for increased demand and opportunities created by electrification of transport.

Develop national supply chain guidelines for electric vehicles and new technologies including battery components or renewable feedstocks for biofuels, and align to international initiatives. Nationally-agreed guidelines would support development of sustainable, ethical supply chains to underpin rollout of new technologies.

The extensive survey of literature in the field identifies a broad consensus as to the solutions necessary for the transformation of Australia’s transport networks. By synthesising the available research into twelve recommendations, this report makes that consensus actionable. Its emphasis on solutions with an applicability across the sector provides real opportunities for decision-makers to forge paths to zero-emissions transport.
## Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Executive summary</td>
<td>4</td>
</tr>
<tr>
<td><strong>INTRODUCTION</strong></td>
<td>10</td>
</tr>
<tr>
<td><strong>SECTION ONE:</strong> THE STATE OF TRANSPORT AND EMISSIONS</td>
<td>13</td>
</tr>
<tr>
<td>Australia’s transport system enables connectivity and growth</td>
<td>14</td>
</tr>
<tr>
<td>Investments in zero-emissions transport provide benefits beyond climate</td>
<td>15</td>
</tr>
<tr>
<td>change action</td>
<td></td>
</tr>
<tr>
<td>Transport emissions</td>
<td>15</td>
</tr>
<tr>
<td>COVID-19 shows rapid changes are possible</td>
<td>17</td>
</tr>
<tr>
<td><strong>SECTION TWO:</strong> ESTABLISHED OPPORTUNITIES</td>
<td>18</td>
</tr>
<tr>
<td>Transformational decade</td>
<td>19</td>
</tr>
<tr>
<td>Around the world, countries and cities are taking bold steps toward</td>
<td>20</td>
</tr>
<tr>
<td>zero-emissions transport</td>
<td></td>
</tr>
<tr>
<td>opportunities in Australia</td>
<td>22</td>
</tr>
<tr>
<td><strong>PASSENGER ROAD AND RAIL TRANSPORT</strong></td>
<td>24</td>
</tr>
<tr>
<td><strong>FREIGHT ROAD AND RAIL TRANSPORT</strong></td>
<td>30</td>
</tr>
<tr>
<td><strong>AVIATION</strong></td>
<td>34</td>
</tr>
<tr>
<td><strong>SHIPPING</strong></td>
<td>35</td>
</tr>
</tbody>
</table>
SECTION THREE: EMERGING OPPORTUNITIES 36
Getting to zero emissions by 2050 37
Emerging zero-emissions transport opportunities in Australia 38

RECOMMENDATIONS: FOCUS AREAS IN THE DECADE FOR CLIMATE ACTION 48

References 52

PASSENGER ROAD AND RAIL TRANSPORT 39

FREIGHT ROAD AND RAIL TRANSPORT 42

AVIATION 44

SHIPPING 45
Transport in Australia is changing and emissions are growing. Demand for transport is increasing as Australia’s population expands and urbanises, priorities shift and technology impacts our lives.¹ Transport emissions can be reduced in line with climate commitments, as the sector evolves to provide for Australia’s emerging needs.

This report was largely prepared in a pre-COVID-19 world, but we acknowledge the immense global shift due to the pandemic. The unprecedented global response has rapidly changed transport networks, political decision-making, economic priorities and the way our lives are shaped. Many of the consequences of this period in history will not be fully realised or understood for months or years to come. However, the conclusions this report draws remain clear and important for informing a post-COVID-19 world.

Transport is the fastest growing and third largest source of emissions in Australia, behind electricity and stationary energy sectors.² Achieving zero emissions in transport will be crucial for Australia to reach a net zero emissions economy.

Net zero emissions refers to reducing economy-wide emissions to zero, or as close to zero as possible, through well-established opportunities and support for emerging solutions, and offsetting any remaining emissions (for example, through carbon forestry).

As a signatory to the Paris Climate Agreement, Australia is committed ‘to keeping a global temperature rise this century to well below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius’.³ All Australian state and territory governments have set goals or aspirations to reach net zero emissions by 2050 or earlier.⁴

Climate science highlights the importance of pursuing 1.5 degrees Celsius, due to the magnified increase in impacts between 1.5 and 2 degrees Celsius of warming (see Box 1).⁵ For Australia, a ‘well below 2 degrees Celsius’ trajectory requires net zero emissions by 2050.
For transport, contributing to this net zero emissions future means achieving zero emissions for the sector by:

+ Reducing demand by avoiding transport trips where possible
+ Shifting to lower emissions transport modes and efficient transport networks
+ Improving energy efficiency
+ Employing zero-emissions fuel sources through renewable powered or fuelled electric, hydrogen and biofuel vehicles.

The solutions needed to transform Australia’s transport networks are known, with many ready to be implemented this decade. Widespread, rapid adoption of well-established strategies along with mature and demonstrated technologies can achieve much of what is needed this decade. Substantial investment in research, development and commercialisation can close the gap to zero emissions across the transport sector by 2050.

Many zero-emissions transport solutions are already being rolled out. Policy, infrastructure and market measures can drive mode shift to more efficient transport modes such as public transport or freight rail. Electrification, hydrogen and biofuels can address emissions in road, rail, aviation and shipping.
Warmer temperatures, higher sea levels and more frequent and intense extreme weather events all put stress on transport systems. Modelling by Australia’s Bureau of Meteorology and CSIRO indicates consistent, ongoing and long-term climate change in Australia as a result of emissions from human activity. Decision-makers and advisors such as Infrastructure Australia are already considering resilience in infrastructure planning and delivery.

Climate change is impacting Australia’s transport networks. As the 2019-20 summer bushfires demonstrated, the impact to transport networks reduced access to food, fuel and movement to safety. The cost of the damage to transport infrastructure is still to be counted.

A comprehensive analysis on the physical impacts of climate change for transport infrastructure is beyond the scope of this paper. It is critical to acknowledge the importance of planning, designing and building resilience in transport infrastructure and services alongside our transition to a net zero emissions future.

The case studies presented in *Moving to Zero: Accelerating the transition to zero-emissions transport* show there are existing opportunities for Australia’s transport network that are both resilient to climate change, and support the transition to zero emissions across all transport networks.

---


† During the 2019-20 summer, Australia was impacted by bushfires from the east to west coast, including the only sealed road linking Western Australia and South Australia. See more: https://www.abc.net.au/news/2020-01-03/nullarbor-road-closures-to-last-five-days-causing-food-shortages/11837324
SECTION 01:
THE STATE OF TRANSPORT AND EMISSIONS
Australia’s transport system enables connectivity and growth

Transport is essential for societies, communities and economies to flourish. An effective transport system enables the efficient, safe, affordable and sustainable movement of people and goods. Australia’s transport system seeks to meet these needs in the context of a rapidly changing nation. Unexpected disruptions to our transport networks, such as the 2020 global COVID-19 pandemic, can interrupt long-term trends and provide an opportunity for the transport sector to evolve through and beyond crisis points.

Key trends facing Australia’s transport systems include:

+ Increasing urbanisation
+ An ageing population
+ Increasing uptake of flexible working patterns
+ Increasing off-peak travel
+ Better access to real-time transport information.

These trends, combined with overall population growth, are increasing the demand for the key transport modes in Australia: road, rail, aviation and shipping. Convenience is a major consideration for passenger and freight transport decisions.

Access to transport options impact access to employment, education and cultural activities, the cost of living, and quality of life through air quality, noise, stress and time spent in transit. London’s Ultra Low Emission Zone only allows low emissions vehicles to drive in the inner city, and has seen a 36% decrease in air pollution, 3-9% reduction in traffic, and a 13% reduction in CO2 emissions.

Australia’s private and public sectors are investing unprecedented amounts into transport infrastructure to keep pace with population growth and increasing transport demands. More than AU$123 billion has been spent on infrastructure since 2015, with over AU$200 billion in the pipeline. Most of this is for new transport infrastructure, with some upgrades and extensions of existing networks.

The ‘predict and provide’ transport approach to travel demand and network capacity means Australia spends above the OECD average on transport infrastructure, in particular on roads. It may be possible to reduce this cost through a combination of demand management, shifting modes and implementing new technologies.

In preparing Australia’s transport system for new technologies and new levels of demand, the sector also needs to prepare for a zero-emissions future. Expenditure on fossil-fuel dependent transport infrastructure – such as roads and diesel railways – can lock in high emissions activities, while public transport and new vehicle charging and refuelling infrastructure can enable emissions reductions. Infrastructure unprepared for a zero-emissions future risks becoming ‘stranded’ due to significant and unanticipated losses of value and faces restricted pools of financing. Infrastructure built today will be in operation for decades to come, while policies and strategies put in place in the coming years will ultimately determine whether zero-emissions transport can be achieved.
Investments in zero-emissions transport provide benefits beyond climate change action

Road congestion currently costs Australian cities billions of dollars a year in lost productivity and impacts quality of life due to time spent in transit.\(^\text{18}\) Increased public transport can help address this. For example, the Gold Coast light rail has reduced traffic volumes on the Gold Coast Highway by 13.9%.\(^\text{19}\) The light rail also increased the value of property within 800 metres of the route by 30% from 1996 to 2016.\(^\text{20}\)

Shifting passengers from road transport to rail can also mean fewer accidents each year. KiwiRail found moving people and freight by rail rather than road in New Zealand provided a net safety benefit of NZ$60-68 million, and eliminated 271 safety incidents annually.\(^\text{21}\)

Assessments of the employment and economic impacts of transportation spending has found public transport and road repairs produce more jobs compared to building new roads\(^\text{22}\). In Adelaide, Precision Buses is designing and manufacturing electric buses to use on public transport systems in five Australian states and supporting worker transitions from the now-closed Holden car factory.\(^\text{23}\)

Amenity and health outcomes will also be improved through reduced noise and better air quality, as will overall access to affordable transport. Barcelona’s Superblocks urban and transport planning strategy aims to ‘reclaim public space for people, reduce motorized transport, promote sustainable mobility and active lifestyles, provide urban greening and mitigate effects of climate change’ and has found the transformation reduces exposure to harmful pollution, noise and heat while increasing physical activity and access to green space.\(^\text{24}\)

The UNDP’s Sustainable Development Goals (SDGs) highlight the importance of Sustainable Cities and Communities (Goal 11) in an increasingly urbanised world. The SDGs are interconnected, and action to address one goal provides opportunities to impact others.

Transport emissions

In the year to June 2019, emissions from the direct combustion of fuels in transport were 18.9% of total national emissions (100.4 Mt CO\(_2\)e), making it the third biggest contributor, behind electricity and stationary energy sectors in Australia.\(^\text{25}\)\(^\text{29}\) Transport emissions have increased by at least 63.5% (39.0 Mt CO\(_2\)e) between 1990 and June 2019, making transport Australia’s fastest growing sources of emissions.\(^\text{26}\) This is faster than Australia’s population growth rate over the same period.\(^\text{21}\) Official government projections predict additional growth of 7% over the next decade to 2030 (see Figure 1).

These statistics exclude indirect emissions from electric vehicles and Australia’s share of international aviation and shipping. Together, these forms of transport are estimated to represent an additional 20.4 MtCO\(_2\)e.\(^\text{27}\) The remainder of this report excludes international aviation and shipping but includes transport-related electricity emissions. These indirect emissions will increase in importance in the coming decades as vehicle fleets are electrified.

The statistics referred to in this report predate COVID-19. At publication, data on the impact of COVID-19 on transport emissions were not yet available. There are predictions that the pandemic will have significant impacts on the transport sector.\(^\text{28}\) Scenarios showed Australian aviation emissions halving due to COVID-19 responses.\(^\text{29}\) The situation continues to evolve with no clarity yet on the impacts or outcomes.\(^\text{30}\) However, there is also the opportunity for action to ensure emissions do not rise significantly in the post-crisis response.\(^\text{31}\)

\(\text{‡} \quad \text{The biggest sources of emissions are electricity (33.8%) and stationary energy (18.9%)}\)

\(\text{§} \quad \text{Based on population growth from 17 million in 1990 to 25 million in 2019}\)
Australia has the third highest transport emissions per capita in the world (excluding aviation), following the United States and Canada.33 Australia’s aviation emissions are the highest per capita in the world, at approximately 0.9 tCO$_2$e per year per person.34 Around 81% of Australia’s transport emissions are from road vehicles (see Figure 1). Growing diesel consumption in road transport, particularly passenger and light commercial vehicles (such as utility vehicles) is a major contributing factor to Australia’s transport emissions.35

Australia’s road vehicle fleet is one of the most energy- and emissions-intensive fleets in the world. Australia’s average emissions intensity for passenger vehicles is 45% higher than Europe,36 and it is one of only six OECD (Organization for Economic Cooperation and Development) countries without vehicle emissions standards.37

Electric vehicles account for 0.6% of Australia’s vehicle fleet, as compared to 3.8% in Europe and 4.7% in China.38 Australia can overcome existing barriers to electric vehicle uptake with increased national coordination and support.39 The tide is turning, with a 203% increase in electric vehicle purchases between 2018 and 2019.

Over the same period, fossil-fuelled car sales declined 7.8%.40 Policies like the ACT Government’s fleet transition to zero-emissions vehicles by 2021 are driving change.41

While Australia’s non-road transport emissions are much lower than those from road vehicles, the rate of growth in recent years has been much higher. Demand across water transport, aviation and rail is anticipated to continue growing in the absence of societal behaviour change, mode shift and technology development.42

Australia’s predominantly car-dependent society locks in a high-carbon transport system, with research exploring processes that contribute and maintain this suggesting some key characteristics and reinforcing linkages: the automotive industry, the provision of car infrastructure, land use pattern choices reinforcing urban sprawl, undermining of public transport provision, and the culture of car consumption.43 Addressing this carbon-intensive transport system requires concerted and coordinated action by governments, business and individuals.

‘Other transport’ includes off-road recreational and pipeline transport.
COVID-19 shows rapid changes are possible

Moving to zero: Accelerating the transition to zero-emissions transport brings together research and resources based on trends over decades of transport changes. It is now evident that trends in the sector can rapidly change in the face of an unexpected and hugely disruptive crisis. The 2020 global coronavirus pandemic is one such example. It is important to consider the opportunities set out in this report to focus our rebuilding efforts from COVID-19 on supercharging the transition to a zero-emissions transport network.

Zero-emissions options are available and feasible, however without clear intervention and direction, post-crisis transport systems could rebound and return to emissions-intensive modes. Initial reports from the end of COVID-19 lockdown in China suggest similar or higher car sales numbers and traffic congestion returning. Following the 2008 Global Financial Crisis, the American President Obama stipulated that stricter fuel efficiency standards were required by some car manufacturers as part of government financial assistance bailout programs. This reduced pollution across the industry.

Similar requirements should be implemented as part of conditions for financial support in the transport industry in Australia, for example, supporting manufacturers in building electric vehicles, transitioning airlines to use low carbon fuels, designing more fuel-efficient vehicles and improving transport network route design.

Our rapid adjustment in this crisis suggests moving to a zero-emissions transport network can occur now. Cities are reimagining the streetscape to support less crowded transport modes such as cycling. The current context provides a unique opportunity to re-examine our streets and city design are set to achieve the zero-emissions transport outcomes.

Green recovery programs can focus on immediate actions to protect health, create jobs and create more liveable active cities long-term. Packages can build on existing active travel network plans and be implemented at all levels of government in Australia.

COVID-19 has also raised questions about the governance of transport systems. Transport companies have been hit hard and are seeking state intervention to safeguard their ability to operate in the future. This could provide an unexpected opportunity for governments to accelerate zero-emissions opportunities. An injection of public funds into private businesses provides government leverage to focus on zero-emissions opportunities. Some countries are also talking about this as an opportunity for re-nationalising these institutions, giving the state direct oversight on emissions reductions.

When Australia, and the world, transitions into a post-crisis rebuilding period, it will be paramount to avoid ‘locking in’ carbon emissions and instead build a zero-emissions economy. Support for building public transport, high-speed rail, active travel infrastructure, incentives for zero-emissions vehicles, and digital infrastructure to support remote working patterns should be prioritised over additional road building, airport expansions or incentives for diesel and petrol vehicles. How and when this post-crisis moment arrives is not yet clear at publication of this report, but this report provides a suite of options that can all be rolled out in the rebuilding of Australia’s post-coronavirus economy.
In the coming decade to 2030, action in the transport sector, is crucial for Australia and the rest of the world to meet the goals of the Paris Climate Agreement. Accelerated action by governments, business and individuals is needed now if global temperature rise is to be limited to well below 2 degrees Celsius.

This section sets out established opportunities for Australia’s transport sector and related emissions, and explores the issues and outcomes related to these zero-emissions transport opportunities.

Unlocking the potential for a zero-emissions transport sector requires bringing together a fragmented and complex sector towards a common goal. ClimateWorks advises government, business and research institutions to come together around the recommendations identified in each section to set Australia up for a zero-emissions transport future.
A significant transformation is required in the coming decade to set the transport sector on a path to zero emissions. Without strategic intervention, Australia’s transport emissions are projected to grow by 7% this decade, reaching 108 Mt CO2e in 2030 (as shown in Figure 1). By contrast, in ClimateWorks’ 1.5 degrees Celsius compatible pathway, transport emissions peak this decade and then quickly decline.

### TABLE 1: BENCHMARKS OF PROGRESS TOWARDS NET ZERO TRANSPORT EMISSIONS BY 2050

<table>
<thead>
<tr>
<th>BENCHMARK</th>
<th>2C PATHWAYS</th>
<th>1.5C PATHWAY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2030 CHANGE</td>
<td>2030 CHANGE</td>
</tr>
<tr>
<td></td>
<td>VERSUS 2020</td>
<td>VERSUS 2020</td>
</tr>
<tr>
<td>TECHNOLOGY BENCHMARKS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electric cars (battery electric vehicles and fuel cell electric vehicles)</td>
<td>50% of new-car sales, 15% of total fleet</td>
<td>2020 = &lt;1% of sales and total fleet</td>
</tr>
<tr>
<td>Electric trucks (battery electric vehicles and fuel cell electric vehicles)</td>
<td>25-39% of new-truck sales, 8-13% of total fleet</td>
<td>2020 = &lt;1% of sales and total fleet</td>
</tr>
<tr>
<td>Volume of zero-emissions fuels (bioenergy and hydrogen)</td>
<td>83-111 PJ</td>
<td>171-265% increase</td>
</tr>
<tr>
<td>ENERGY BENCHMARKS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Share of electricity and zero-emissions fuels in total transport energy use</td>
<td>9-11%</td>
<td>2020 = 3%</td>
</tr>
<tr>
<td>Share of electricity and zero-emissions fuels in road passenger and freight energy use</td>
<td>5-9%</td>
<td>2020 = 2%</td>
</tr>
<tr>
<td>Fossil fuel use in non-road transport</td>
<td>226-233 PJ</td>
<td>5-8% decrease</td>
</tr>
<tr>
<td>EMISSIONS BENCHMARKS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total transport emissions</td>
<td>108-115 MtCO2e</td>
<td>2-9% increase**</td>
</tr>
<tr>
<td>Road transport emissions</td>
<td>89-95 MtCO2e</td>
<td>5-12% increase††</td>
</tr>
<tr>
<td>Other transport emissions</td>
<td>18.8-19.5 MtCO2e</td>
<td>5-8% decrease</td>
</tr>
</tbody>
</table>

** Emissions peak in 2025, and decline consistently afterwards.
†† Emissions peak between 2025-2027, and decline consistently afterwards.
Achieving the modelled scenario would include immediately accelerating the roll out of mature and demonstrated zero-emissions technologies (Table 1). Electric vehicles comprise the majority of new light vehicle sales by 2030, and together with the transition to renewable powered electricity, provide rapid decarbonisation of passenger transport. For example, in the modelled 1.5 degrees Celsius scenario, 76% of the light vehicles bought between 2025 and 2030 are battery electric vehicles (BEV). By 2030, 28% of all light vehicles on the road are BEVs. This is higher than government projections, which anticipate 19% of new car sales will be battery electric or plug-in hybrid in 2030, making up 6% of the total fleet. The modelled scenarios assume electric vehicles reach cost parity with fossil fuelled cars sooner than conservative assumptions suggest, reflecting the continual outperformance of battery technologies against historical projections and the need for accelerated roll out of more mature and demonstrated technologies under this climate target.

Biofuel and hydrogen fuel sources play a larger role in heavy road vehicles, aviation and shipping under the modelled scenarios. Mainstream use of biofuels is assumed to begin by 2030.

The scenarios presented in Decarbonisation Futures are only a small selection of many pathways that could deliver a transport sector compatible with well below 2 degrees Celsius of warming. Decarbonisation Futures focuses specifically on technological innovations and regulatory policy mechanisms. Future scenario modelling is needed to explore the emissions-reduction potential of other policy mechanisms, as well as urban planning, infrastructure and service provision decisions.

RECOMMENDATION:
DEVELOP A SHARED VISION
(strategies, targets and frameworks)

The development of a shared vision of a desired zero-emissions transport system can support planning and delivery of transport infrastructure and services, and be enabled through developing future scenarios or facilitating forums to develop plans.

Around the world, countries and cities are taking bold steps toward zero-emissions transport

Sixteen countries – and counting – have taken steps toward phasing out fossil-fuel powered cars, including scheduled bans on new fossil-fuelled car sales in the UK, France, China, and India. Countries are also introducing incentives for electric vehicle sales such as Japan, South Korea, Ireland and Denmark. Norway electric vehicle incentives have had broad support across governments since the 1990s and have led to a 50% market share in 2018. Incentives include tax reductions or subsidies on vehicles, road taxes and tolls, and parking; financial compensation for scrapping fossil-fuelled vehicles; and infrastructure for charging, parking and priority road access.

Countries have also set modal shift targets to prioritise zero-emissions transport options, mobilising financing, infrastructure and other resources to meet the challenge. France has committed to tripling cycle use over the six years to 2024, from 3% today to 9% of the transport modal share. Global expansion of rail has increased with rail infrastructure investment tripling between 2005 and 2015, providing additional access to low emissions transport options. China has led growth for both urban and high-speed rail construction. Globally rail travel mode share has remained constant at 8%, even while overall motorised transport demand has grown, demonstrating that rail can provide a convenient, cost-competitive, zero-emissions transport option even as demand for transport increases.

In addition, cities are leading the way with transport emissions solutions. The C40 coalition of cities committed to ambitious climate action currently represents 650 million people and 25% of the world’s
GDP and can deliver 40% of the savings needed to keep climate change to 1.5 degrees Celsius.61

More than 30 major cities around the world have pledged to buy only zero-emissions buses from 2025, including London, Los Angeles, Auckland, Jakarta, and Moscow. This builds on the example China has set, the Chinese city of Shenzhen, with a population of 12 million people, has fully electrified their bus fleet with 16,000 electric buses in eight years.62

Vehicle manufacturers are also setting targets for zero-emissions vehicle models; and have invested US$300 billion in the electrification of global vehicle models.63 Volvo has committed to 50% of new vehicle sales to be electric cars, alongside working to become a carbon-neutral company by 2040, covering manufacturing, operations, and supply chain.64 The 12-brand Volkswagen Group, which includes Audi, Porsche and Bentley, plan to release 70 fully electric vehicle models by 2030, while the company is aiming for carbon neutrality by 2050 across their entire fleet production and administration operations.65

Global alliances also provide a platform for collaboration, information-sharing and increasing ambition. The Transport Decarbonisation Alliance unites members for ambitious, tangible and effective action in the transport sector.66

The EV100 initiative brings together companies committed to transition to electric vehicles.67 As businesses own half of new registered vehicles on the road, EV100 sees the huge potential for companies to lead on fleet transitions to electric vehicles. EV100 members have switched to over 80,000 electric vehicles.68

While international maritime shipping emissions are not covered by the Paris Climate Agreement, the International Maritime Organisation has targets to reduce emissions.69 In aviation, the UN specialised agency, the International Civil Aviation Organization, set a global aspirational goal of carbon-neutral growth in aviation emissions from 2020 onwards to be achieved through aircraft technology improvements, operational improvements, sustainable aviation fuels, state-based action plans and market-based measures.70 Norway is aiming to operate all of its short-haul flights (under 1.5 hours) using 100% electricity by 2040.71

Australia risks falling behind these global efforts. There is a wealth of global support and experience that can be employed to tackle Australia’s transport emissions. Now is the moment to seize the opportunity.

‡‡ Under the Carbon Offsetting and Reduction Scheme for International Aviation (Corsia), airlines are expected to set baselines for emissions reductions on 2020 levels. Given COVID-19 impacts on the airline industry, the baseline could be set very low requiring more effort to meet targets, and risking airlines pulling out of the scheme. Seeking agreement from all stakeholders remains vital for addressing emissions from international aviation. See more:
Established zero-emissions transport opportunities in Australia

Many established opportunities are ready to be implemented this decade. Widespread, rapid adoption of well-established strategies along with mature and demonstrated technologies can achieve much of what is needed this decade.

Australia’s passenger and freight kilometres can be reduced, and shifted to more efficient modes. Remaining emissions can be eliminated through the use of renewable-powered electricity and zero-emissions fuels. Rolling out established opportunities can achieve emissions reductions this decade, and can be accelerated immediately. With increased research, development and demonstration investment this decade, Australia will be set up to fully reach zero emissions across the entire transport sector between 2030 and 2050.

Changes in planning, infrastructure, service provision, investment and regulatory frameworks are needed for the zero emissions transition to happen. Greater communication and information sharing between stakeholders can accelerate this process. Interstate collaboration is necessary for Australia-wide projects to be effective, such as rail network pricing or electric vehicle charging infrastructure. There is also scope for sharing lessons on transport emissions issues and opportunities—in particular, among state and territory governments which have all set aspirations or targets for net zero emissions by 2050 at the latest.72

Table 2 below defines the scope of what is discussed in this established opportunities section.
## TABLE 2: OPPORTUNITY NAVIGATION INDEX

<table>
<thead>
<tr>
<th>ESTABLISHED OPPORTUNITIES</th>
<th>EMERGING OPPORTUNITIES</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PASSENGER TRANSPORT: ROAD AND RAIL</strong></td>
<td></td>
</tr>
<tr>
<td>+ Mode shift</td>
<td>+ Renewable hydrogen fuel cell electric vehicles</td>
</tr>
<tr>
<td>+ Transport demand management</td>
<td>+ Possible support by emerging technologies</td>
</tr>
<tr>
<td>+ Planning policy</td>
<td></td>
</tr>
<tr>
<td>+ Fuel efficient fossil-fuelled vehicles</td>
<td></td>
</tr>
<tr>
<td>+ Renewable-powered electric passenger vehicles</td>
<td></td>
</tr>
<tr>
<td><strong>LAND FREIGHT: ROAD AND RAIL</strong></td>
<td></td>
</tr>
<tr>
<td>+ Mode shift</td>
<td>+ Renewable-powered electric light and heavy commercial vehicles</td>
</tr>
<tr>
<td>+ Load management</td>
<td>+ Renewable hydrogen fuel cell electric vehicles</td>
</tr>
<tr>
<td>+ Planning policies</td>
<td>+ Biofuels</td>
</tr>
<tr>
<td>+ Fuel efficient fossil-fuelled vehicles</td>
<td>+ Possible support by emerging technologies</td>
</tr>
<tr>
<td><strong>AVIATION</strong></td>
<td></td>
</tr>
<tr>
<td>+ Mode shift</td>
<td>+ Renewable-powered electric aircraft</td>
</tr>
<tr>
<td>+ Avoid trips</td>
<td>+ Renewable hydrogen fuel cell electric aircraft</td>
</tr>
<tr>
<td>+ Load management</td>
<td>+ Biofuels</td>
</tr>
<tr>
<td>+ Flight path efficiency</td>
<td></td>
</tr>
<tr>
<td>+ Local commerce</td>
<td></td>
</tr>
<tr>
<td>+ Vehicle design for energy efficiency</td>
<td></td>
</tr>
<tr>
<td><strong>SHIPPING</strong></td>
<td></td>
</tr>
<tr>
<td>+ Local commerce</td>
<td>+ Renewable-powered electric ships</td>
</tr>
<tr>
<td>+ Route efficiency</td>
<td>+ Renewable hydrogen fuel cell electric ships</td>
</tr>
<tr>
<td>+ Vehicle design for energy efficiency</td>
<td>+ Biofuels</td>
</tr>
</tbody>
</table>
Passenger transport moves millions of Australians every day, including in private cars, public transport, and active transport modes such as walking and cycling.73

Australia can shift to a zero-emissions passenger transport network at the same time as meeting the demands of a growing and urbanising population.

Avoiding trips where possible, shifting to more efficient transport modes, and improving technology performance all have a role to play in meeting growing demand while reducing emissions.

REDUCE DEMAND AND IMPROVE EFFICIENCY

Transport demand management strategies,74 planning, infrastructure, services and market incentives are key levers to reduce passenger transport emissions and meet future challenges.

PLANNING AND STRATEGIES

Australia’s land use planning system is determined through strategic and statutory planning policies. These provide both long-term strategic visions for states and cities, and specific statutory rules to guide development. The planning system is critical to transport because it shapes where, when and how Australians travel.

In the planning stage, established opportunities to address identified passenger transport needs can be chosen to meet a zero emissions future. These options include building new infrastructure, expanding existing infrastructure, altering service provisions, or employing policy mechanisms.75 These options can be utilised across Australian jurisdictions, though may need to be tailored to specific states, territories and local government areas. Achieving zero emissions can be identified as a primary planning objective, in state planning frameworks, metropolitan plans such as the Greater Sydney Commission, or local government strategies.

Some planning mechanisms that can address passenger transport emissions include precinct and city master plans that actively consider emissions, zoning and growth policies such as Melbourne’s Urban Growth Boundary, priorities for transit-oriented developments around existing transport hubs, and building and planning controls such as minimum parking requirements. The Victorian Transport Integration Act (2010) requires the state to establish an action plan for transport planning.76 A transport plan which incorporates the whole-of-government emissions-reduction pledge from the Victorian Climate Change Act (2017) can set the state’s transport network up for a zero emissions future.77

Government targets for emissions reductions alone do not necessarily translate into transport outcomes. An assessment of targets in the cities of Copenhagen and Portland found clear climate change mitigation strategies and targets for the transport sector, at multiple levels of government, were still not adequately reflected in transport investment priorities.78 However, this may be changing due to growing public concern of environmental issues, greater economic pressure, and increasing public scrutiny of transport decision making.79 These trends provide decision-makers with an opportunity to move away from projects that lock in emissions, to supporting zero-emissions transport options. In post-COVID-19 economic recovery, tight budgets should prioritise green recovery by investing in zero-emissions transport options.

Active travel modes (walking, bike riding and scooters) provide opportunities to decrease emissions. The design of urban environments to include access to public transport, green space and local amenities has the potential to enhance the health and well-being of residents.80 Towns and regions can transform their transport behaviours quickly with leadership, resourcing and ongoing implementation.81 For example, Seville in Spain increased the city’s cycling infrastructure from 12km of paths in 2005 to 120km in 2010. In 2011, over 70,000 daily bicycle trips were recorded.82 Mode share showed bicycle trips rose from 3.2% to 8.9%, public transport trips increased 4% and private car trips fell 11%.83
In expanding Australian cities, emissions outcomes should be prioritised when planning future transport to meet travel demand induced by new residential areas or increased density. This can be achieved through increased public transport services powered by renewable energy, dedicated active transport infrastructure, and electric vehicle charging stations powered by renewable energy. The German railway company Deutsche Bahn is committed to using 100% renewable energy for rail operations by 2038.84

As the Sydney CBD undergoes disruption during the construction work of the Metro train and light rail network, Transport for NSW worked with business and employers to develop travel plans and resources for avoiding driving during peak periods.85 The Travel Choices behaviour change program has seen a 12% reduction in vehicles travelling to the CBD during the morning peak hour, and 11% increase in public transport use since 2015.85

Planning for zero-emissions transport opportunities should also acknowledge the vulnerability of some community members to transport disadvantage. In Australia, transport disadvantage refers to ‘ongoing difficulties associated with access to transport... [and] difficulties associated with maintaining private transport (for example, financial stress related to initial cost of purchase, as well ongoing costs such as petrol, insurance and maintenance)’.87 Particularly vulnerable communities include families with young children, people with a disability, older people, those on low incomes, Indigenous Australians, and those in geographic locations such as outer-urban, rural or remote areas.

**INFRASTRUCTURE AND SERVICES**

Australia’s public and private sectors are making unprecedented investments into transport infrastructure, such as railways, roads, airports, bridges, ports, tunnels and walking and cycling paths.88 Given the long lived nature of these assets, and their influence on travel behaviour, it is vital the pipeline of transport infrastructure enables emissions reductions.89

Infrastructure and service provision shapes the set of transport options available to people. Efficient and reliable mass rapid electric transit systems, such as light rail, bus, metro and long-distance rail networks, can shift individuals from private road transport to public transport. Sydney Metro NorthWest rail line is predicted to reduce emissions from transport by avoiding 14 million car trips by 2021, and sourcing 100% of operational electricity through a Power Purchasing Agreement with First Solar.90

Creating attractive public transport networks means improving service frequencies, reliability, accessibility of services and modal changes, last mile connectivity, safety, fares and pricing. Bogota’s Bus Rapid Transit system successfully increased public transport use from 64% in 1999 to 70% in 2005 through constructing 82 kilometres of exclusive busways on trunk corridors and high-quality rail-like stations, and introducing free fare transfers between feeder and trunk services.91

Other benefits include reducing travel times across the city, a reduction in traffic accidents, increasing property values around bus stations, and reducing NOx by 18% and particulate matter by 12%. These works are part of the first two phases, with a further six phases planned. Phase one was funded with a local 25% fuel surcharge (46% of investment), general local revenues (28%), grants from the National Government (20%) and a loan from the World Bank (6%).92

The opportunity is not limited to just transport infrastructure. Energy infrastructure is needed to facilitate the electrification of vehicles, such as cars and buses. The Queensland Electric Super Highway provides fast charging infrastructure every 100-200 kilometers from Coolangatta to Cairns, near amenities and tourist attractions, with power for the chargers sourced from green energy credits or offsets.93

Conversations amongst sector stakeholders on the role of infrastructure in supporting net zero emissions are in their early stages. ClimateWorks Australia, the Infrastructure Sustainability Council of Australia (ISCA) and Australian Sustainable Built Environment Council (ASBEC) are currently working to facilitate these conversations, with an aim to reshape Australia’s infrastructure sector for a net zero emissions future.94

**PRICE SIGNALS AND REGULATIONS**

Policies, subsidies and pricing mechanisms can support behaviour change to more efficient transport modes and zero-emissions vehicles.

Price signals can incentivise choices to encourage more efficient use of transport systems and support uptake of zero-emissions technologies. The introduction of congestion charging in London, Stockholm and Milan have led to reductions in emissions and pollution of 13-18%. All cities announced and implemented plans for the charge revenue to go to sustainable mobility (public transport, bike lanes and pedestrian areas); and the schemes saw decreases in traffic compared to the baseline year of 14-38.5%, and uptake of public transport of 10-12.5%.95 The Grattan Institute has recommended the introduction of congestion charging in Australian cities.96

Regulation such as vehicle emissions standards
can play a role in enabling all transport users to benefit from innovations by transport sector leaders who are already delivering zero-emissions vehicles. Toyota, Volvo and Subaru have all set targets for manufacturing and selling electric vehicles (which have zero tailpipe emissions). New Zealand’s 2021 package of a Clean Car Standard and Clean Car Discount will put a fee on new high polluting car sales, the revenues from which will be used to fund subsidies of new lower-emissions vehicles, helping avoid five million tonnes of emissions. Australia remains one of only six OECD countries that do not regulate vehicle emissions.

Australia’s Ministerial Forum on Vehicle Emissions was established in 2015 to coordinate a whole-of-government approach. No mandatory emissions standards have, however been adopted in Australia to bring fuel standards in line with international best practice. Now is an opportunity for Australia to build on existing work by the Ministerial Forum on Vehicle Emissions to implement best practice standards.

**RECOMMENDATIONS:**

**ALIGN GOVERNMENT AND BUSINESS STRATEGIES**

( Strategies, targets and frameworks)

Transport strategies, targets and frameworks and business strategies are aligned to zero emissions and sustainable development targets.

**PRIORITISE NET ZERO EMISSIONS IN STRATEGIC AND STATUTORY PLANNING**

( Strategies, targets and frameworks)

Strategic and statutory planning frameworks align with zero emissions targets for cities, settlements, transport systems, infrastructure, and service provision.

**SHIFT PRIVATE VEHICLE TRIPS TO PUBLIC, ACTIVE AND SHARED TRANSPORT OPTIONS**

( Shifting the network)

Movement of people uses efficient, zero-emissions transport options through improved service provision, subsidies, funding options and other measures.
ELECTRIC PASSENGER VEHICLES

Electrification is the most mature and demonstrated technology for rapidly reducing transport emissions. Combined with a renewable-powered electricity grid, electric vehicles can play a pivotal role in bringing passenger transport emissions to zero.

Electrification has been demonstrated as economically viable at scale for transport journeys, such as passenger trains, light rail, cars, motorcycles, bicycles and buses.

Electric vehicles are vehicles powered by electricity instead of, or in addition to, liquid fuels. There are four main types of electric vehicles:

+ Battery electric vehicles (BEVs) are fully electric with batteries charged by being plugged into an external power outlet
+ Fuel cell electric vehicles (FCEVs) have an electric motor but are powered by a hydrogen or another liquid fuel instead of, or in addition to, a battery
+ Plug-in hybrid electric vehicles (PHEVs) have both an internal combustion engine that uses liquid fuel and a battery that can be charged with electricity
+ Hybrid electric vehicles (HEVs) are the same as PHEVs with an internal combustion engine that uses liquid fuel, the electric component used to start the ignition.

Electric vehicle purchases in Australia increased by 203% between 2018 and 2019. By contrast, there has been a 22-month decline in fossil-fuelled car sales. Despite this increase in uptake, electric vehicles only make up 0.6% of Australia’s vehicle fleet, compared to 3.8% in Europe and 2.3% in New Zealand.

The upfront cost of electric vehicles remains high in Australia, with the majority of available passenger models costing over AU$60,000. But prices continue to decline due to production efficiencies and design optimisation, alongside declining costs of batteries (the most expensive component of an electric vehicle). Electric passenger cars purchase cost is expected to become cost competitive or even cheaper than conventional vehicles by the mid-2020s.

While the upfront costs of electric vehicles are higher than conventional vehicles, their operating costs are less than half, on average. Electricity is cheaper than fossil fuels, and electric vehicles have lower maintenance costs.

For high-mileage drivers, such as taxi and ride-share drivers, electric vehicles are already cost-competitive when the total cost of ownership is taken into consideration. In the UK, Nottingham’s Council Taxi Strategy will only license Ultra Low Emission Vehicles (ULEVs) taxis from 2025. To support the transition there is financial support, a ‘try before you buy’ program and a network of public charging points (including wireless charging to reduce wait times, minimising work disruption).
Electric buses are currently underutilised in most countries, including Australia. They can reduce costs, improve air quality and support local industries.\textsuperscript{111} China represents 99\% of the global market for electric buses with examples such as the city of Shenzhen transitioning 16,000 buses to a fully electric bus fleet through the support of national and municipal government subsidies; affordable leasing arrangements with manufacturers and; optimised fleet charging to reduce operational costs.\textsuperscript{112} In 2019, the NSW Government announced plans to electrify Sydney’s fleet of 8,000 buses.\textsuperscript{113}

Australia can overcome existing barriers to electric vehicle uptake with increased national coordination and support.\textsuperscript{114} To address perceptions of vehicle range anxiety and poor access to charging infrastructure, Australia can increase public education about electric vehicles and increase provision of public charging stations. Infrastructure Australia has called for the fast-tracking of a national charging network.\textsuperscript{115}

The upcoming Australian National Strategy for Electric Vehicles presents a key opportunity for governments to establish mechanisms to accelerate electric vehicle uptake, including recommendations put forth by the Senate Select Committee on Electric Vehicles report.\textsuperscript{116} Financial incentives, pricing mechanisms, and vehicle emissions standards are all levers to help accelerate the transition to electric vehicles. As the Technology Roadmap discussion paper outlines, Australia brings local capabilities in world-leading vehicle design and manufacturing for fast chargers and vehicle retrofits.\textsuperscript{117}

\section*{ELECTRIC VEHICLE FLEET STRATEGIES}

Government and business fleets make up 52\% of annual new vehicle sales in Australia, and serve as an important source to the second-hand market.\textsuperscript{118} Fleet procurement guidelines have a large influence on the future composition of Australia’s total vehicle fleet.

Due to their relatively low operating costs, electric vehicles are currently feasible for government and business fleets. ClimateWorks’ analysis for Victorian local governments found that for most light vehicle types, including hatchbacks, sedans, wagons, sport utility vehicles, vans and minibuses, there is an electric vehicle model within or below local council total cost of ownership guidelines.\textsuperscript{119}

Fleet electrification commitments have environmental, economic, health and reputational benefits for government and businesses. Commitments also demonstrate national appetite for electric vehicles to carmakers, support growth of a second-hand market for electric cars, and can provide necessary impetus for the increased provision of charging infrastructure.\textsuperscript{120}

Charge Together Fleets is a program, co-developed by Energeti and the Electric Vehicle Council with funding from ARENA, to assist businesses, governments and councils with electrifying their fleets.\textsuperscript{121} There are now over 200 fleets and 300 registered users – including NRMA and Transgrid – which provides peer-to-peer learning opportunities, as well as online tools such as a total cost of ownership calculator that compares electric vehicles to fossil-fuelled vehicles.\textsuperscript{122}

\section*{GREATER INTEGRATION OF TRANSPORT AND ELECTRICITY GRID}

Increased uptake of electric vehicles will see greater integration of Australia’s electricity and transport networks. Electric vehicles can be integrated into the grid as a battery source and be a net positive for Australia’s electricity networks. While electric vehicles will increase overall electricity demand, they can also absorb surplus generation from solar PV during the day and return it to the grid at a later time. This allows for greater renewable penetration and improving grid stability and resilience.\textsuperscript{123} The average electric vehicle can store approximately 60 kilowatt hours (kWh) of energy, enough to provide back-up power to an average household for two days.\textsuperscript{124} Vehicle-to-grid integration capability needs further focus to understand the impact on overall battery life, new infrastructure requirements, metering systems and policies to manage demand.\textsuperscript{125}

Changes to electricity demand from electric vehicles can also be managed through demand-side interventions and grid stability infrastructure. Dynamic pricing and smart remote charging can allow consumers to turn charging off and on in response to prices, flattening demand in the process.\textsuperscript{126} Greater understanding of consumer responses to demand management is an area for future research.

Demand from bus and larger vehicle fleets can also be mitigated with onsite depot energy storage and solar PVs, as well as opportunity charging (fast charging during service at interchanges or along routes) reducing the load at depots and peak grid demand times.\textsuperscript{127} Analysis conducted for the City of

\section*{JUNE 2020 | ESTABLISHED OPPORTUNITIES |}
Auckland found it is possible to mitigate or avoid local grid stabilisation upgrades to meet increased grid demand from electric bus charging.\textsuperscript{128}

Coordination between transport and energy sector stakeholders is required to ensure electric vehicles are efficiently integrated into the electricity network. The Australian Renewable Energy Agency’s (ARENA) Distributed Energy Integration Program is bringing together stakeholders to work on smooth integration of electric vehicles into existing networks and markets.\textsuperscript{129}

**SUPPLY CHAIN CONSIDERATIONS**

As production of electric vehicles is scaled up, the sustainability of their supply chains need to be carefully managed.\textsuperscript{130}

Emissions embodied in the production of electric vehicles batteries can be mitigated through increased reuse and recycling. Currently, only 2\% of Australia’s annual 3,300 tonnes of lithium-ion battery waste is recycled. If recycled, 95\% of components can be turned into new batteries or used in other industries.\textsuperscript{131} In Japan, used electric vehicle batteries are being used for a variety of functions, such as powering remote street lights and convenience store fridges.\textsuperscript{132}

The Australian Battery Stewardship Council is working with industry and government to implement a Battery Stewardship Scheme to improve the rate of battery recycling.\textsuperscript{133} Lithium Australia subsidiary Envirosteam is successfully recycling battery metals from lithium-ion batteries in their Melbourne factory.\textsuperscript{134}

The extraction of rare minerals required for battery production, such as cobalt and lithium, also raises environmental and ethical issues to be navigated. Lithium reserves require hazardous chemicals to be extracted, which can impact soil, water and the surrounding ecosystem.\textsuperscript{135} Cobalt has similar environmental issues, and is predominately sourced from the Democratic Republic of Congo, where supply chains are notorious for instability, corruption and child labour.\textsuperscript{136}

At the World Economic Forum 2020, 42 international organisations endorsed 10 guiding principles toward a vision for a sustainable global battery chain by 2030.\textsuperscript{137} These principles include ensuring the circular recovery of battery materials and eliminating child and forced labour from supply chains.\textsuperscript{138}

---

**RECOMMENDATIONS:**

**REVIEW FINANCIAL INCENTIVES AND PRICING MECHANISMS**

(Improving vehicles)

Active support for zero-emissions passenger vehicles, such as subsidies or road-user pricing.

**DEVELOPMENT AND IMPLEMENTATION OF VEHICLE EMISSIONS STANDARDS**

(Improving vehicles)

Vehicle emissions standards implemented in line with international best practice.

**DEVELOP NATIONAL SUPPLY CHAIN GUIDELINES**

(Improving vehicles)

Sustainable, ethical supply chains support rollout of new technologies.

**PLAN FOR AND MANAGE INTEGRATION OF ELECTRIC VEHICLES WITH AUSTRALIA’S ELECTRICITY NETWORKS**

(Improving vehicles)

Energy networks prepared for increased demand and opportunities created by electrification of transport.
Freight transport refers to the movement of imported and local goods for domestic use, as well as Australia’s export supply chains, transport modes and facilities.139

Demand for freight is increasing. Total domestic freight volumes have grown by 571% from 1970 to 2015-16, and are projected to grow by 25% between 2018 and 2040.140 This is being driven by factors such as Australia’s export market, growing population, and increased e-commerce transactions and consumer expectations of fast delivery. The freight industry is evolving from separate haulage, warehousing and distribution firms into integrated logistics companies, some of which are multi-modal. Growth from 2017 to 2018 in the number of online purchases was 20.2% and it is estimated that e-commerce sales will continue to double every five years.141

Freight emissions can be decoupled from economic growth and freight demand. Effective long-term planning, shifting freight to zero-emissions modes and strategies that improve overall efficiency all have a role to play in bringing freight transport emissions to zero.

**REDUCE DEMAND AND IMPROVE EFFICIENCY**

Freight transport emissions can be reduced through effective long-term planning, shifting freight to zero-emissions modes and strategies that improve overall efficiency.

**PLANNING AND STRATEGIES**

Australia’s freight network coordinates the daily movement of large volumes through capital-intensive infrastructure. It does so as trends such as automation, new export demands, and shifting consumer expectations of fast delivery impact the sector. Long-term planning is essential to achieving emissions reductions while meeting other outcomes like profitability and productivity.

Reducing freight emissions can be prioritised in key strategic, statutory and infrastructure planning documents. These provide strategic visions for Australia’s development at a national, state, and city level, and guide land use allocations, transport corridors and infrastructure provisions. These options can be utilised across Australian jurisdictions, although state-specific contexts will require tailoring to fit their context. Key documents include the National Freight and Supply Chain Strategy, as well as location-specific development plans like the Murray Basin Freight Rail Project.142

**MODE SHIFT**

Shifting freight from road to rail, where possible, is a key strategy to reduce freight emissions. It will lead to immediate emissions reductions, even before the potential of low-emissions fuel or renewable electricity-powered rolling stock is fully realised. The global average energy intensity of freight rail (as measured by energy use per million tonne kilometres) is less than one-third of that of medium and heavy trucks.143 In the case of freight travel from Port Botany to Greater Sydney, an extra rail service is estimated to take 54 trucks off the road.144

Improved infrastructure is one way to shift freight volumes to rail. Metropolitan intermodal terminals and increased rail investment can encourage the use of rail for non-bulk items in capital cities, a market currently monopolised by road freight.145 The Victorian Government’s Mode Shift Incentive Scheme funds rail projects to encourage shifting from road to rail freight.146 There is an opportunity for similar grants to be offered across Australia, as has been done in the United Kingdom147 and Europe.148

Infrastructure is also required to create zero-emissions freight rail lines, and remaining road freight. Currently, only 10% of Australia’s freight rail is electrified, with the remaining 90% powered by fossil fuels. Electrification, and future zero-emissions fuels like hydrogen and biofuels, will be central to bringing road and rail freight emissions to zero. Their uptake can be facilitated through the provision of refuelling and charging infrastructure at ports, airports, truck terminals, rail terminals, intermodal facilities, distribution hubs and along key freight routes.149
Standardising pricing frameworks between road and rail networks would encourage freight to shift to the most efficient mode. Rail freight pays access charges based on the costs borne by rail infrastructure developers and operators, while road freight is charged based on fuel use and registration fees. This leads to inconsistencies and difficulties in comparing options.\textsuperscript{150} Thirty-five per cent of submissions to the Government’s Inquiry into National Freight and Supply Chain Priorities highlighted the need to address road pricing reform in order to achieve ‘modal neutrality’.\textsuperscript{151}

As is the case for passenger transport, mode shifting freight from road to rail will have co-benefits in terms of safety, congestion and costs. Rail is twenty times safer than articulated trucks for moving freight.\textsuperscript{152} Addressing freight congestion, safety, vehicle noise, pollution and emissions are key issues in maintaining social license to operate in residential areas.\textsuperscript{153}

**NETWORK EFFICIENCY**

Efforts to improve efficiency in the freight sector will also reduce emissions. Efficiency can be improved by reducing unnecessary kilometres, freight load-management technology, greater data transparency and increased communication and coordination between stakeholders in the sector.\textsuperscript{154}

Innovative ways to reduce unnecessary freight kilometres will minimise both costs and emissions. For example, in some highly urbanised areas, up to 50\% of parcel supply chain costs relate to ‘last mile’ issues.\textsuperscript{99} \textsuperscript{155} Opportunities can reduce freight costs and emissions like using urban consolidation centres to bring together goods from multiple suppliers or parcel pick-up lockers with 24/7 customers access.\textsuperscript{156}

The transparent collection and sharing of data, such as through the forthcoming National Freight Data Hub initiative, can contribute to emissions reductions if emissions data is included. Understanding the emissions and costs related to certain operational or investment options can help businesses and governments make optimal decisions.\textsuperscript{157}

Facilitating coordination both across and within modal freight industries, some of which have tens of thousands of operators, could bolster efforts to optimise efficiency and reduce emissions. For example, freight rail shares infrastructure with passenger train paths and often cedes priority, creating delays that deter greater use of rail.\textsuperscript{158} *** Transport for NSW has highlighted that more efficient allocation could be achieved through better information exchange and inclusion of freight rail operators in rail use negotiations.\textsuperscript{159}

While these opportunities may seem broad and complex in usual times, in emergency times there are opportunities to make changes. The COVID-19 crisis highlights the importance of the seamless urban movement of people and goods for the resiliency of our economy. It has made it possible to reexamine networks to meet requirements such as ensuring the steady supply of food, medical supplies and emergency goods. Transport networks have and must adapt quickly, building a holistic view of how the network interacts to ensure resilience is maintained. These adjustments can enable a more efficient, less polluting network in the long term. Digitisation and connectivity are key to enabling a seamless mobility system moving forward. Disruption from the COVID-19 crisis includes changing patterns in online shopping, domestic and international flights, food delivery industry, and changes in regional freight networks, agribusiness supply chains and global supply chain risks.\textsuperscript{160} Post-COVID-19 economies can focus on ‘green recovery’ to implement and develop zero-emissions transport opportunities.

**TRANSITION RISKS AND OPPORTUNITIES**

An important consideration for freight transport is the emissions associated with the goods it moves. In the transition to a zero-emissions economy, demand will increase for some goods and decrease for others.

Demand for commodities such as lithium and cobalt, which are required for batteries and solar panels and for which Australia has rich resources, are expected to increase exponentially.\textsuperscript{161} On the other hand, 75\% of Australia’s bulk rail network services the export of iron and coal.\textsuperscript{162} International demand of these commodities may decline significantly as companies and governments enact stricter carbon policies.\textsuperscript{163}

Freight transport companies and infrastructure providers can use scenario analysis and other tools to explore the compatibility of the goods they serve with a zero emissions world. ClimateWorks’ Net Zero Momentum Tracker – Transport sector report provides a basis for transport companies to discuss and develop net zero emissions targets, and compare against their peers.\textsuperscript{164}

\textsuperscript{¶¶} Getting deliveries from centralised nodes to customers’ doors

\textsuperscript{***} The wider road freight transport sector has an estimated 42,000 operators
**RECOMMENDATIONS:**

**ALIGN GOVERNMENT AND BUSINESS STRATEGIES**
(Strategies, targets and frameworks)

Transport strategies, targets and frameworks and business strategies are aligned to zero emissions and sustainable development targets.

**PRIORITISE NET ZERO EMISSIONS IN STRATEGIC AND STATUTORY PLANNING**
(Strategies, targets and frameworks)

Strategic and statutory planning frameworks align with zero emissions targets for cities, settlements, transport systems, infrastructure, and service provision.

**SHIFT FREIGHT FROM ROAD TO RAIL**
(Shifting the network)

Movement of goods uses efficient, zero-emissions transport options through improved service provision, subsidies, funding options and other measures.

**COORDINATION BOTH BETWEEN AND WITHIN FREIGHT STAKEHOLDERS TO REDUCE EMISSIONS**
(Shifting the network)

Communication and information sharing across and within government and business stakeholders optimise efficiency of freight sector.
ELECTRIC LIGHT COMMERCIAL VEHICLES

Electrification is the most mature and demonstrated technology for rapidly reducing transport emissions. Combined with a renewable-powered electricity grid, electric vehicles can play a pivotal role in bringing transport emissions to zero. For more background information see Electric passenger vehicles.

Electrification has been demonstrated as economically viable at scale for short-haul freight transport journeys, such as light commercial vehicles (vans).

Electric light commercial trucks (vans) purchase cost is expected to become cost-competitive or even cheaper than conventional vehicles by the mid-2020s. The upfront cost of electric vehicles remains high in Australia, however prices continue to decline due to production efficiencies and design optimisation, alongside declining costs of batteries (the most expensive component of an electric vehicle).

While the upfront costs of electric vehicles are higher than conventional vehicles, their operating costs are less than half, on average. Electricity is cheaper than fossil fuels, and electric vehicles have lower maintenance costs. For high-mileage drivers, such as taxi and ride-share drivers, electric vehicles are already cost-competitive when the total cost of ownership is taken into consideration. In the UK, Nottingham’s Council Taxi Strategy will only license Ultra Low Emission Vehicles (ULEVs) taxis from 2025; to support the transition there is financial support, a ‘try before you buy’ program and a network of public charging points (including wireless charging to reduce wait times, minimising work disruption).

Due to their relatively low operating costs, electric vehicles are currently feasible for government and business fleets. ClimateWorks’ analysis for Victorian local governments found that for most light vehicle types, including hatchbacks, sedans, wagons, sport utility vehicles, vans and minibuses, there is an electric vehicle model within or below local council total cost of ownership guidelines.

Government and business fleets make up 52% of annual new vehicle sales in Australia, and serve as an important source to the second-hand market. Fleet procurement guidelines have a large influence on the future composition of Australia’s total vehicle fleet.

Fleet electrification commitments have environmental, economic, health and reputational benefits for government and businesses. Commitments also demonstrate national appetite for electric vehicles to Carmakers, have positive flow-on effects in the second-hand car market, and can provide necessary impetus for the increased provision of charging infrastructure. Since 2017, Australia Post began to transition their fleet vehicles, with plans to be the largest fleet operator of electric vehicles in Australia. The fleet includes almost 6,000 vehicles, with electric push bikes and three-wheeled electric delivery vehicles that better support parcel delivery as mail preferences change.

Electric vans for use by logistics and freight companies are being built here in Australia. SEA Electric, based in Victoria with facilities in Dandenong and support for a factory and training facilities in the Latrobe Valley, are electrifying delivery vans and rubbish trucks.

Increased uptake of electric vehicles will see greater integration of Australia’s electricity and transport networks. Demand from larger vehicle fleets can also be mitigated with onsite depot energy storage and solar PVs, as well as opportunity charging (fast charging during service at interchanges or along routes) reducing the load at depots and peak grid demand times. Analysis conducted for the City of Auckland found it is possible to mitigate or avoid local grid stabilisation upgrades to meet increased grid demand from electric bus charging.

RECOMMENDATIONS:

REVIEW FINANCIAL INCENTIVES AND PRICING MECHANISMS
(Improving vehicles)

Active support for zero-emissions vehicles, such as subsidies or road-user pricing.

DEVELOP ZERO-EMISSIONS FLEET STRATEGIES FOR GOVERNMENT AND CORPORATE VEHICLE Fleets
(Improving vehicles)

Government and corporate vehicle fleets (electric cars and public transport rolling stock) transition to electric fleets powered with renewable-energy and invest in charging infrastructure, enabling broader uptake of electric vehicles.
Aviation

Air freight accounts for less than 1% of international freight in terms of volume, but 21% of the freight in terms of value due to high priced items. Demand is expected to continue growing for timely delivery of items such as high value manufacturing and mining products, and perishables such as food, urgent medical products and market flowers.

Aviation emissions need to be decoupled from economic growth and demand. Effective long-term planning, setting up the industry to shift to zero-emissions fuels, and strategies that improve overall efficiency all have a role to play in bringing aviation emissions to zero. Most solutions are still emerging, such as alternative fuels.

**REDUCE DEMAND AND IMPROVE EFFICIENCY**

Addressing passenger aviation emissions includes reducing the need for flights. Communications infrastructure such as video conference facilities can replace the need for frequent physical travel. The National Geographic has set out business travel policies to substitute travel suggesting:

- Teleconferencing, videoconferencing and using web-based communications tools; travel only when absolutely necessary; combine multiple tasks into one trip; and use the most fuel-efficient, low emissions and economical transportation possible.
- Domestic flights can be shifted to more efficient modes such as high-speed intercity rail modes.
- Between 2012-15 China’s domestic aviation emissions are estimated to have reduced 3-5% due to mode shifting to high-speed rail. High-speed rail lines can reduce aviation activity on the same corridors by as much as 80% within a short time frame of becoming operational. Research by Beyond Zero Emissions suggests a high-speed rail connection along Australia’s east coast could reduce emissions by 3.5 million tonnes.

Network efficiency improvements in shipping can bring emissions reductions. Flight paths optimisation, aerodynamics, vehicle design and weight minimisation all play a role in making the sector more efficient.

Infrastructure that facilitates electrification and switching to zero-emissions fuels can be built today. Refuelling infrastructure at ports and airports is also needed to enable and normalise the use of alternative fuels such as biofuels and hydrogen.
Freight shipping volumes account for 98% of Australia’s total international trade, and 74% in terms of value. Demand is expected to continue growing for timely delivery of items such as high value manufacturing and mining products, and perishables such as food, urgent medical products and market flowers.

Shipping emissions can be decoupled from economic growth and demand. Effective long-term planning, setting up the industry to shift to zero-emissions fuels, and strategies that improve overall efficiency all have a role to play in bringing shipping emissions to zero. Most solutions are still emerging, such as alternative fuels.

The IMO has been requiring emissions reductions in international shipping through the Energy Efficiency Design Index, which provides new build ship design efficiencies standards. As these measures are limited to new ships, it will take decades to cover the entire shipping fleet; additionally, many large ships have already met the 2030 target well in advance, suggesting the efficiency standards are not particularly ambitious.

Infrastructure that facilitates electrification and switching to zero-emissions fuels can also be built today. Refuelling infrastructure at ports is also needed to enable and normalise the use of alternative fuels such as biofuels and hydrogen.

Network efficiency improvements in shipping can bring emissions reductions. Operational efficiencies can be gained through improved ship design, engine efficiencies, load management and route optimisations to reduce freight kilometres for shipping.
Substantial investment in research, development and commercialisation can close the gap to zero emissions across the transport sector by 2050. Zero-emissions fuels like hydrogen and biofuels can eliminate emissions across modes. Emerging technology and disruptors need guidance now to ensure they lead to a zero-emissions transport sector.

This decade is crucial to set up Australia’s transport sector for reaching zero emissions by 2050. Australia can prepare for emerging technologies, growing transport demand, and the physical impacts of climate change, alongside zero-emissions transport opportunities.

This section sets out emerging opportunities, potential transport technology solutions, and explores the issues and outcomes they present for reaching a zero-emissions transport sector.

Unlocking the potential for a zero-emissions transport sector requires bringing together a fragmented and complex sector towards a common goal. ClimateWorks advises government, business and research institutions come together around the recommendations identified in each section to advance policy, research and implementation that will set Australia up for a zero-emissions transport future.
Getting to zero emissions by 2050

ClimateWorks’ Decarbonisation Futures research has explored a range of future scenarios for Australia compatible with Australia reducing emissions in line with well below 2 degrees Celsius of warming. The research includes the transport sector, and shows that a zero-emissions transport sector in Australia is possible by 2050 (with the exception of relatively small emissions from aviation and legacy road vehicles). This will require concerted and coordinated effort by governments, business, and society at large.

A significant transformation is required in the coming decade to set the transport sector on a path to zero emissions. Without strategic intervention, Australia’s transport emissions are projected to grow by 7% this decade, reaching 108 Mt CO2e in 2030 (as shown in Figure 1). By contrast, in ClimateWorks’ 1.5 degrees Celsius compatible pathway, transport emissions peak in 2025 before a sharp decline, approximately halving from the 2025 peak by 2035.

Achieving this under the modelled scenario would include rapidly developing and commercialising emerging zero-emissions technologies. Biofuel and hydrogen play a larger role in heavy road vehicles, aviation and shipping under the modelled scenario. Mainstream use of biofuels is assumed to begin in 2030, reaching a penetration of 44% of aviation fuel and 25% of shipping fuel by 2040.

In passenger transport by 2050, 18.6 million battery electric vehicles are on the road (compared to approximately 35,000 in 2020).

The scenarios presented in Decarbonisation Futures are only a small selection of many pathways that could deliver a transport sector compatible with well below 2 degrees Celsius of warming. The modelled scenarios focus specifically on technological innovations and regulatory policy mechanisms. Future scenario modelling is needed to explore the emissions reduction potential of other policy mechanisms, as well as urban planning, infrastructure and service provision decisions. More detailed modelling of the emissions impact of technological disruptions such as autonomous vehicles and ride sharing is also needed.

RECOMMENDATION:

DEVELOP A SHARED VISION
(Strategies, targets and frameworks)

The development of a shared vision of a desired zero-emissions transport system can support planning and delivery of transport infrastructure and services, and be enabled through developing future scenarios or facilitating forums to develop plans.

§§§ ClimateWorks’ modelled 1.5 degrees Celsius scenario is compatible with a 50% chance of limiting temperature rise to 1.5 degrees Celsius
Emerging zero-emissions transport opportunities in Australia

To reach zero emissions across the transport sector by 2050, there are many established opportunities already discussed that can set the sector on a zero emissions pathway. There are also emerging opportunities that require further investment in research, development and commercialisation to close the gap to zero emissions across the transport sector by 2050.

The transformational decade is vital in setting up the pathway to zero emissions with established opportunities, and providing time to develop and guide emerging technologies to contribute to 2030.

Table 3 below defines the scope of what is discussed in this emerging opportunities section.

**TABLE 3: OPPORTUNITY NAVIGATION INDEX**

<table>
<thead>
<tr>
<th>ESTABLISHED OPPORTUNITIES</th>
<th>EMERGING OPPORTUNITIES</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PASSENGER TRANSPORT: ROAD AND RAIL</strong></td>
<td><strong>+ Renewable hydrogen fuel cell electric vehicles</strong></td>
</tr>
<tr>
<td>+ Mode shift</td>
<td>+ Possible support by emerging technologies</td>
</tr>
<tr>
<td>+ Transport demand management</td>
<td></td>
</tr>
<tr>
<td>+ Planning policy</td>
<td></td>
</tr>
<tr>
<td>+ Fuel efficient fossil-fuelled vehicles</td>
<td>+ Renewable-powered electric light and heavy commercial vehicles</td>
</tr>
<tr>
<td>+ Renewable-powered electric passenger vehicles</td>
<td>+ Renewable hydrogen fuel cell electric vehicles</td>
</tr>
<tr>
<td><strong>LAND FREIGHT: ROAD AND RAIL</strong></td>
<td>+ Biofuels</td>
</tr>
<tr>
<td>+ Mode shift</td>
<td>+ Possible support by emerging technologies</td>
</tr>
<tr>
<td>+ Load management</td>
<td></td>
</tr>
<tr>
<td>+ Planning policies</td>
<td>+ Renewable-powered electric light and heavy commercial vehicles</td>
</tr>
<tr>
<td>+ Fuel efficient fossil-fuelled vehicles</td>
<td>+ Renewable hydrogen fuel cell electric vehicles</td>
</tr>
<tr>
<td><strong>AVIATION</strong></td>
<td>+ Biofuels</td>
</tr>
<tr>
<td>+ Mode shift</td>
<td>+ Renewable-powered electric aircraft</td>
</tr>
<tr>
<td>+ Avoid trips</td>
<td>+ Renewable hydrogen fuel cell electric aircraft</td>
</tr>
<tr>
<td>+ Load management</td>
<td>+ Biofuels</td>
</tr>
<tr>
<td>+ Flight path efficiency</td>
<td></td>
</tr>
<tr>
<td>+ Local commerce</td>
<td></td>
</tr>
</tbody>
</table>
Passenger road and rail transport

Emerging technologies could reduce passenger emissions to zero, but more research and investment is needed to understand the full impact.

RENEWABLE FUELS

Hydrogen, biofuels and other low emissions fuels have a key role to play in improving the emissions outcomes of certain transport modes. With the right supply chains, hydrogen and biofuels can be zero-emissions fuels. The full extent of zero-emissions fuels is still an emerging opportunity. More investment in research and development is required to progress zero-emissions fuels.

Hydrogen passenger cars and buses have been developed, but their capital and operating costs are expected to remain above those of their battery-electric alternatives.195

RECOMMENDATION:
SUPPORT RESEARCH, COMMERCIALISATION, AND STANDARDS
(Improving vehicles)

Research, commercialisation, and standards to support the development and roll out where viable renewably-fuelled zero-emissions vehicles.

OTHER TECHNOLOGY AND DISRUPTORS

Other emerging and ‘disruptive’ transport technologies are new innovations with the potential to create significant and rapid change in transport systems and cities.196

Transport systems are both facing significant technological change.197 Along with electrification and alternative fuels, emerging and disruptive technologies including automation, ride sharing, ride sourcing, transport applications, mobility-as-a-service, drone delivery, and other innovations are redefining how people and goods are moved. The current atmosphere of change caused by the COVID-19 pandemic presents an opportunity for reducing emissions to be prioritised as transport systems are reconfigured.

The advent of new technologies, such as ride-sourcing Uber deliveries and drone deliveries, bring significant uncertainty as to how these will reconfigure transport infrastructure, and flow on effects for emissions.198 For example, the introduction of ride sourcing platforms in cities can add to traffic and attract passengers away from public transport, walking and cycling.199 Analysis shows that ride sourcing trips are 69% more polluting than the trips they replace as a result of vehicles driving more with no passengers and because they replace lower-carbon modes such as walking, cycling and public transport. Companies and policymakers can address this through using trips to access public transport, electrifying vehicles and pooling trips.200 New transport technologies also raise concerns regarding safety, privacy and the use of data.201 The increasing use of contractors to deliver services also raises questions about worker protections and safety.202

While many such technologies are market-led, governments can play a proactive role in deciding whether and how disruptive technologies are applied in Australia to meet transport objectives, including zero emissions. This may involve governments adapting planning and regulatory processes to manage potential social, economic and environmental impacts from new innovations and seeking community input.203
Autonomous vehicles, sharing platforms and mobility-as-a-service have the potential to shape future emissions reductions if paired with zero-emissions vehicles and introduced in complement with public transport, rather than as its competitor.\(^{204}\)

Other emerging technologies and disruptors heading to Australia include:

- Drone delivery applications, such as Google Wing\(^{205}\)
- Food delivery applications, such as UberEats and Deliveroo\(^{206}\)
- Helicopter commuter services, such as UberAir\(^{207}\)
- Increased use of contractors to undertake transport services, such as Amazon Flex\(^{208}\)
- Micromobility, such as human-powered vehicles, such as bicycles, skates, skateboards and kick-scooters\(^{209}\)

**AUTOMATION**

Automated vehicles are capable of driving themselves without intervention from a human driver.\(^{210}\) International standards of driving automation range from zero or ‘driver support’ (for example, blind spot warning) to five or ‘fully automated driving under all conditions’ (for example, driverless taxi).\(^{211}\) Vehicle connectivity to other vehicles is an important enabling factor for automation to realise emissions reductions.

Automation is already at work in our transport system. Freight logistics facilities use automated equipment to unload, organise and load cargo, and some public transport is automated, such as Sydney Metro’s driverless trains.\(^{212}\)

The private and public sectors are investing in the development and use of autonomous vehicles, especially in road transport. The NSW Government has allocated AU$10 million over four years to trials for connected and automated vehicles.\(^{213}\) But further research, consultation and collaboration is needed to resolve regulatory issues. As the National Transport Commission noted, there are over 700 regulatory barriers to autonomous vehicle uptake in different state, territory and federal laws; in particular, regulation tends to separate vehicles and drivers, while for autonomous vehicles, these are one and the same.\(^{214}\)

The effect autonomous vehicles will have on emissions in Australia is unclear.\(^{215}\) Various international studies offer estimates of the impact autonomous vehicles will have on emissions, ranging from 2-25% reduction or 3-20% increases.\(^{216}\) There remain gaps in understanding how autonomous vehicles will impact overall vehicle kilometres, vehicle ownership rates, fuel use and more broadly how transport systems will evolve to include autonomous vehicles.\(^{217}\) In order to minimise emissions impacts, combining autonomous vehicles with electric technology and shared models of ownership are needed.\(^{218}\)

Research and modelling often looks ahead to future scenarios in which high autonomous vehicle uptake has already been achieved, leaving questions about the transition while autonomous vehicles and human drivers share the road, and what impact this will have on emissions.\(^{219}\)

**SHARING PLATFORMS**

Sharing our travel journey is not new. Mass public transport options such as trains and buses have existed for hundreds of years.\(^{219}\) Since the mid-20th century there has been rising private car use, and in response, transport network companies have recast the idea of sharing travel in a private context.

Types of sharing platforms that have emerged include:

- Ridesharing (or car-pooling) - connects drivers and passengers with similar origins and destinations, such as Liftango for city commuters, or Share Your Ride for long distance carpooling between cities
- Ride-sourcing (or ride-hailing) - connects drivers and passengers, on demand and as a paid service for example, Uber, Ola and Didi
- Ride-splitting platforms - allows multiple passengers to share a ride-sourcing trip at a reduced price, for example, UberPOOL
- Car sharing - allows private car owners to rent their vehicles for short periods of time, for example, GoGet and Car Next Door
- Bike or scooter sharing - provides bicycles or scooters for short term hire, for example, Lime, oBikes.

Shifting to more efficient transport modes such as bikes or scooters, or car-pooling, should be prioritised in a zero-emissions transport system. However, ride sharing/sourcing is the most popular of the emerging platforms. In 2018, 21% of Australians used a private ride sharing service over a three-month period.\(^{220}\) While there is increasing

\(^{204}\) For example, Infrastructure Victoria (2018) Advice on Automated and Zero Emissions Vehicles model only considered impacts from 2031-2046.
scrutiny over new on demand service platforms, the focus is on workers’ safety and business impacts. The Inquiry into the Victorian On-Demand Workforce background paper does not mention the implications for congestion or emissions.221

There is a lack of data on the emissions impact of sharing platforms, but recent research found ride-hailing trips create 70% more pollution than the trips they displace.222 International evidence also suggests ridesharing increases congestion. While ridesharing replaces solo car travel in some instances, it often encourages additional journeys and reduces public transport use. Ridesharing companies were found to be the central cause of a 62% increase in congestion in San Francisco between 2010 and 2016.223 Over the same period public transport use decreased in the city, and similar trends have been observed in other cities.224

MOBILITY-AS-A-SERVICE

Mobility-as-a-Service (Maas) systems are integrated digital platforms used to plan, book, and pay for transport modes and services.225 Subscribers can connect to a range of transport options (such as, public transport, taxi, car rental, car sharing and bike share) in one place, regardless of their owners or operators, with pricing models from pay-as-you-go through to unlimited travel options.

The emissions impact of these new services is not clear due to limited use in Australia and minimal research on emissions impacts. Studies focus on the reduction of vehicle kilometres travelled, which may result from consumers switching their transport mode away from private cars to shared or public transport modes. This could have consequences for emissions, but outcomes are uncertain without clear policy that prioritises zero-emissions transport modes. Maas application ‘Whim’ has been operating in Helsinki, connecting many of the city’s transport options (public transport, taxi, car rental, car sharing, and city bike) in one subscription and one app. Some key findings are that public transport is the key for Maas, representing 95% of all Whim trips; Maas users are multimodal, often combining different transport modes; ride-hailing (taxi) use rose 2.1 times for Maas users than the average Helsinki residents; and Maas helps solve first/last mile gaps with more taxi and bike trips immediately before and after a public transport trip.226

RECOMMENDATION:

ASSESS AND MANAGE EMISSIONS IMPACTS OF EMERGING AND DISRUPTIVE TRANSPORT TECHNOLOGIES
( Strategies, targets and frameworks)
Prepare for emerging and disruptive technologies, and ensure new technologies align with zero emissions strategies, by developing guidance, policies and regulations for federal, state and local governments.
Freight road and rail transport

For heavy road and rail freight, international case studies and ClimateWorks’ Decarbonisation Futures research show there will be a role for electrification and alternative fuels. Reaching a zero-emissions freight transport sector requires research and investment in emerging opportunities, to progress electrification of heavy vehicles and use of zero-emissions fuels.

ELECTRIC HEAVY VEHICLES

Electrification is still in the development and commercialisation phase for heavy vehicles, freight rail and fire trucks.227 The technology can rapidly reduce transport emissions, and combined with a renewable powered electricity grid, can bring transport emissions to zero. For more background information see ‘Electric passenger vehicles’ and ‘Electric light commercial vehicles’ in ‘Section two: Well-established opportunities’.

Research and pilot projects for rigid and articulated trucks are focused on overcoming current barriers such as the on-board batteries crowding out room for cargo loads, and limited access to charging infrastructure. Daimler AG’s eCascadia is due for volume production in 2021, while the Tesla Semi, which has a range of 800 kilometres, is scheduled for limited production in late 2020. 228

HYDROGEN

Hydrogen is a versatile element used in a variety of applications such as transport fuel and as a raw material in industrial processes. Hydrogen powered the first internal combustion engines some 200 years ago.229 It can be produced using fossil fuels or via zero-emissions means such as electrolysis, a process that uses renewable-powered electricity and water.230 Electrolysis uses significant quantities of energy and water,231 but strategies such as using recycled water can help mitigate impacts on natural resources.232

Hydrogen-fuelled trucks are suitable for long distance journeys, heavy payloads (where the weight of batteries is a disadvantage) and cases where rapid refueling is needed.233 It is estimated that the total cost of ownership for renewable hydrogen heavy-duty trucks will be comparable with the cost of diesel powertrains by 2030.234 Nikola Motor Company has developed a semi-trailer truck able to travel up to 1,900km on a single tank of hydrogen. It is due to be commercially available in 2020. 235

In the case of long distance freight rail, hydrogen may aid the transition away from diesel as the refuelling infrastructure could be cost-competitive with electrification.236 Germany deployed two hydrogen fuel cell trains in 2018, with a contract for fourteen in total by 2021. These trains can travel around 1000km on a single tank of hydrogen.237

The transport sector alone cannot create the supply and demand needed for hydrogen to scale up and create an economically viable industry, but transport applications can play a vital role in stimulating commercial demand for hydrogen across the economy.238 Australia has the resources to produce renewable hydrogen for domestic use, as well as to become a leading global exporter of renewable hydrogen, creating jobs and economic benefits.239

RENEWABLE FUELS

Hydrogen, biofuels and other low-emissions fuels have a key role to play in improving the emissions outcomes of certain transport modes. With the right supply chains, hydrogen and biofuels can be zero-emissions fuels. The full extent of zero-emissions fuels is still an emerging opportunity. More investment in research and development is required to progress zero-emissions fuels.
BIOFUELS AND OTHER ALTERNATIVE FUELS

Biofuels are fuels such as biodiesel and ethanol, which are produced from plant and animal matter such as vegetable oils, corn and animal fats. Other alternative low-emissions fuels include ammonia and renewable-produced methanol and synthetic diesel.

These alternative fuels are at varying levels of technological and commercial readiness. The use of these fuels at scale is promising for the non-road transport modes such as rail.

In some cases, alternative fuels can be used to ‘drop-in’ to existing freight vehicles as a replacement for diesel and other high emissions fuels. These provide options to use existing engines and fuel distribution systems with minor modifications required. This is an important factor for reducing the emissions of existing fleets, some of which have lifespans of over 25 years.

The expansion of alternative fuels use poses some challenges for their supply chains. The feedstocks required for ‘first generation’ biofuels compete for land and water with existing agricultural production. ‘Advanced’ biofuels, made from non-food biomass such as wood residues and waste, avoid some of these externalities but are at an earlier stage of technological maturity.

RECOMMENDATIONS:

SUPPORT RESEARCH, COMMERCIALISATION, AND STANDARDS
(Improving vehicles)
Research, commercialisation, and standards to support the development and roll out where viable renewably-fuelled zero-emissions vehicles.

DEVELOP NATIONAL SUPPLY CHAIN GUIDELINES
(Improving vehicles)
Sustainable, ethical supply chains support rollout of new technologies.

****Chemically-identical substitutes for conventional fuels that do not require engine modification
Aviation

In aviation, international case studies and ClimateWorks’ Decarbonisation Futures research show there will be a role for electrification and alternative fuels. Further investment in research and development is required to progress electrification of aircraft and use of zero-emissions fuels.

**ELECTRIC PLANES**

Electrification is still in the development and commercialisation phase for aviation vehicles. The technology can rapidly reduce transport emissions, and combined with a renewable powered electricity grid, can bring transport emissions to zero. For more background information on electric vehicles generally, see ‘Electric passenger vehicles’ and ‘Electric light commercial vehicles’ in ‘Section two: Well-established opportunities’.

Electric aviation planes, drones, and helicopters have been developed and are in limited use. Current development and trials are focused on short-haul flights. There is a need for further development and research to understand their role in future transport networks. By 2035, the electric aircraft market is estimated to be worth US$22 billion.244 A key area for research is the development of battery storage capability.

The ICAO is monitoring developments as they work towards creating new standards for electric aircraft.245 Australian company Electro.Aero, operated the world’s first commercial electric aircraft flight in 2018.246 Airbus plans to start test flights of their electric 100-seater E-Fan X planes in 2020.247

Electric aircraft also offer additional benefits. Pipistrel’s electric aircraft, the Taurus G4, requires less runway length for take-off than its fuel-powered equivalent.248 Electric planes are also near silent, which allows them to fly and land closer to dwellings – an increase in flexibility that could improve aircraft flight paths, which in turn can reduce fuel consumption for the industry.249

**RENEWABLE FUELS**

Hydrogen and biofuels can be zero-emissions fuels and can play a central role in decarbonising the aviation sector in applications where electrification is not viable.

**HYDROGEN**

Hydrogen is a versatile element used in a variety of applications such as transport fuel and as a raw material in industrial processes. Hydrogen powered the first internal combustion engines some 200 years ago.250 It can be produced using fossil fuels or via zero-emissions means such as electrolysis, a process that uses renewable-powered electricity and water.251 Electrolysis uses significant quantities of energy and water,252 but strategies such as using recycled water can help mitigate impacts on natural resources.253

The use of hydrogen in aviation is being tested, with the National Aeronautics and Space Administration (NASA) committing US$6 million to develop more advanced hydrogen-electric hybrid technology for aircraft.254

The transport sector alone cannot create the supply and demand needed for hydrogen to scale up and create an economically viable industry, but transport applications can play a vital role in stimulating commercial demand for hydrogen across the economy.255 Australia has the resources to produce renewable hydrogen for domestic use, as well as to become a leading global exporter of renewable hydrogen, creating jobs and economic benefits.256

**BIOFUELS AND OTHER ALTERNATIVE FUELS**

Biofuels are fuels such as biodiesel and ethanol, which are produced from plant and animal matter such as vegetable oils, corn and animal fats.257 Other alternative low-emissions fuels include ammonia and renewable-produced methanol and synthetic diesel.
These alternative fuels are at varying levels of technological and commercial readiness. The use of these fuels at scale is promising for the non-road transport modes of aviation.

In some cases, alternative fuels can be used to ‘drop-in’†††† to existing freight vehicles as a replacement for diesel and other high emissions fuels. These provide options to use existing engines and fuel distribution systems with minor modifications required. This is an important factor for reducing the emissions of existing fleets, some of which have lifespans of over 25 years.

Current safety and performance requirements for alternative fuel use in aviation mean they can only be blended with conventional jet fuel. The International Renewable Energy Agency notes that meeting certification standards for sustainable aviation fuels can take years and millions of dollars to complete. These are important requirements for international and national standards that facilitate greater uptake of zero-emissions fuels in aviation and shipping. Five biofuel blends have been approved by the ICAO.††

The expansion of alternative fuels use poses some challenges for their supply chains. The feedstocks required for ‘first generation’ biofuels compete for land and water with existing agricultural production. ‘Advanced’ biofuels, made from non-food biomass such as wood residues and waste, avoid some of these externalities but are at an earlier stage of technological maturity.

While more research and development is needed to bring alternative zero-emissions fuels to the mainstream market, there is momentum in the industry. Alternative jet fuels have been in commercial use in Australia since 2018, and a pilot biorefinery for jet fuel is under construction in Gladstone, Queensland.

**RECOMMENDATION:**

**SUPPORT RESEARCH, COMMERCIALISATION, AND STANDARDS**

(Improving vehicles)

Research, commercialisation, and standards to support the development and roll out where viable renewably-fuelled zero-emissions vehicles.

††††Chemically-identical substitutes for conventional fuels that do not require engine modification
Shipping

For shipping, international case studies and ClimateWorks’ Decarbonisation Futures research show there will be a role for electrification and alternative fuels. Reaching a zero-emissions transport sector requires emerging opportunities. More investment in research and development is required to progress electrific ships and the use of zero-emissions fuels.

ELECTRIC SHIPS

Electrification is still in the development and commercialisation phase for shipping. The technology can rapidly reduce transport emissions, and combined with a renewable powered electricity grid, can bring transport emissions to zero. Current development and trials are focused on shorter ferry trips. There is a need for further development and research to understand their role in future transport networks. For more background information on electric vehicles generally, see ‘Electric passenger vehicles’ and ‘Electric light commercial vehicles’ in ‘Section two: Well-established opportunities’.

A Norwegian local authority recently committing to purchase a fleet of 20 all-electric ferries after the 60 metre electric ferry, Ellen, completed its maiden journey in Denmark in 2019.

RENEWABLE FUELS

Hydrogen, biofuels and other low emissions fuels have a key role to play in improving the emissions outcomes of certain transport modes. With the right supply chains, hydrogen and biofuels can be zero-emissions fuels. These alternative fuels will play a central role in decarbonising shipping, in applications where electrification is not viable.

HYDROGEN

Hydrogen is a versatile element used in a variety of applications such as transport fuel and as a raw material in industrial processes. Hydrogen powered the first internal combustion engines some 200 years ago. It can be produced using fossil fuels or via zero-emissions means such as electrolysis, a process that uses renewable-powered electricity and water. Electrolysis uses significant quantities of energy and water, but strategies such as using recycled water can help mitigate impacts on natural resources.

The EU has provided €5 million in funding for the construction of two zero-emissions hydrogen fuel cell ships in Norway and France.

The transport sector alone cannot create the supply and demand needed for hydrogen to scale up and create an economically viable industry, but transport applications can play a vital role in stimulating commercial demand for hydrogen across the economy. Australia has the resources to produce renewable hydrogen for domestic use, as well as to become a leading global exporter of renewable hydrogen, creating jobs and economic benefits.

BIOFUELS AND OTHER ALTERNATIVE FUELS

Biofuels are fuels such as biodiesel and ethanol, which are produced from plant and animal matter such as vegetable oils, corn and animal fats. Other alternative low-emissions fuels include ammonia and renewable-produced methanol and synthetic diesel.

These alternative fuels are at varying levels of technological and commercial readiness. Research and development of these fuels at scale shows promise for shipping.

In some cases, alternative fuels can be used to ‘drop-in’ to existing freight vehicles as a replacement for diesel and other high emissions fuels. These provide options to use existing engines and fuel distribution systems with minor modifications required. This is an important factor for reducing the emissions of existing fleets, some of which have lifespans of over 25 years.

However, the transition to new ports and refuelling infrastructure is time-, capital- and resource-intensive.

### Chemically-identical substitutes for conventional fuels that do not require engine modification
intensive. LNG bunkering infrastructure, for example, took 10 years to develop but still only supplies 1% of the global shipping fleet. There is an urgent need for international and national standards that facilitate greater uptake of zero-emissions fuels in aviation and shipping.

The expansion of alternative fuels use poses some challenges for their supply chains. The feedstocks required for ‘first generation’ biofuels compete for land and water with existing agricultural production. ‘Advanced’ biofuels, made from non-food biomass such as wood residues and waste, avoid some of these externalities but are at an earlier stage of technological maturity.

While more research and development is needed to bring alternative zero-emissions fuels to the mainstream market, there is momentum in the industry. International shipping conglomerate Maersk will develop commercially viable zero-emissions vessels by 2030, lead industry collaboration, and research into new fuels in order to meet a net zero emissions by 2050 commitment.

RECOMMENDATION:
SUPPORT RESEARCH, COMMERCIALISATION, AND STANDARDS
(Improving vehicles)
Research, commercialisation, and standards to support the development and roll out where viable renewably-fuelled zero-emissions vehicles.

§§§§ Processing and infrastructure needed to supply fuel to ships. Three methods: i) truck-to-ship; ii) ship-to-ship; or iii) shore-to-ship.
FOCUS AREAS IN THE DECADE FOR CLIMATE ACTION
The 2019 United in Science report[^28] found that the current decade is the ‘transformational decade’, when action is crucial for Australia and the rest of the world to meet the goals of the Paris Climate Agreement, including in the transport sector. Concerted and coordinated action by governments, business and individuals needs to begin now if global temperature rise is to be limited to well below 2 degrees Celsius.

This report sets out established opportunities (including mature and demonstrated technologies) that can be adopted in the next decade. It summarises emerging opportunities that require investment in research, development and demonstration in order to close the gap to zero-emissions transport by 2050.

The transport sector is large and fragmented, supporting activity across Australia’s entire economy using a variety of transport modes. As this report shows, there is a wealth of research, case studies and data available across the whole sector to draw on.

By bringing together opportunities for a zero-emissions transport sector in the one reference point, this report highlights both the common features and unique opportunities between passenger and freight, road, rail, aviation and shipping sub-sectors. Common areas for action that feature throughout this report are:

- Aligning strategies, planning and frameworks with zero-emissions transport networks
- Shifting transport networks to support more efficient and shared mobility mode choices, through infrastructure, services and pricing mechanisms
- Improving vehicles to run at zero-emissions.

Table 4 provides details of ClimateWorks Australia’s 12 recommendations for the transport sector under these three broad themes. Some of these recommendations relate to one part of the transport system, others relate across the whole sector, as summarised in the right-hand column. Each recommendation responds to a gap between the current state of play (as described in Sections 2 and 3) and future potential for a zero emissions transport system, as detailed in the table.

Overall, unlocking the potential for a zero-emissions transport sector requires bringing together a fragmented and complex sector towards a common goal. If government, business and research institutions come together around recommendations listed below to advance policy, research and implementation, this would set Australia up for a zero-emissions transport future.
<table>
<thead>
<tr>
<th>CURRENT DOMINANT STATE OF PLAY</th>
<th>FUTURE POTENTIAL</th>
<th>RECOMMENDATION</th>
<th>RELEVANT SECTORS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uncertainty on how to plan for a future zero-emissions transport system, and the required supporting policies and technology</td>
<td>Coordinated vision for future zero-emissions transport systems to ensure a smooth and timely transition</td>
<td>DEVELOP A SHARED VISION of a desired zero-emissions transport system, to support planning and delivery of transport infrastructure and services (e.g. developing future scenarios; facilitating forums to develop plans)</td>
<td>PASSENGER, LAND FREIGHT, AVIATION, SHIPPING</td>
</tr>
<tr>
<td>Lack of or disconnect between emissions reduction strategies, transport strategies and business strategies</td>
<td>Transport strategies, targets and frameworks and business strategies are aligned to zero emissions and sustainable development targets</td>
<td>ALIGN GOVERNMENT STRATEGIES to zero emissions before 2050 for both direct transport operations and broader transport systems</td>
<td>PASSENGER, LAND FREIGHT, AVIATION, SHIPPING</td>
</tr>
<tr>
<td>Lack of or disconnect between emissions reduction targets, and how transport is planned and implemented</td>
<td>Strategic and statutory planning frameworks align with zero emissions targets</td>
<td>PRIORITISE NET ZERO EMISSIONS IN STRATEGIC AND STATUTORY PLANNING for cities, settlements, transport systems, infrastructure, and service provision</td>
<td>PASSENGER, LAND FREIGHT</td>
</tr>
<tr>
<td>Uncertainty on how to prepare for emerging and disruptive transport technologies, and potential emissions impacts</td>
<td>Prepared for emerging and disruptive technologies, and ensuring new technologies align with zero emissions strategies</td>
<td>ASSESS AND MANAGE EMISSIONS IMPACTS OF EMERGING AND DISRUPTIVE TRANSPORT TECHNOLOGIES by developing guidance, policies and regulations for federal, state and local governments</td>
<td>PASSENGER</td>
</tr>
<tr>
<td>Low mode share of efficient transport modes (public, active and shared transport for passengers; rail for freight)</td>
<td>Movement of people and goods uses efficient, zero-emissions transport options</td>
<td>SHIFT PRIVATE VEHICLE TRIPS TO PUBLIC, ACTIVE AND SHARED TRANSPORT OPTIONS, AND SHIFT FREIGHT FROM ROAD TO RAIL, through improved service provision, subsidies, funding options and other measures</td>
<td>PASSENGER, LAND FREIGHT</td>
</tr>
</tbody>
</table>
## Shifts The Network

**Potential for improved freight sector efficiency through data, communication and information sharing across and within government and business stakeholders**

- **CURRENT DOMINANT STATE OF PLAY**: High communication and information sharing across and within government and business stakeholders to optimise efficiency of freight sector.

- **FUTURE POTENTIAL**: Coordination both between and within freight stakeholders to reduce emissions (e.g. with stakeholders for both passenger and freight to coordinate use of train lines; or across modes for intermodal hubs to shift to more efficient trips).

- **RECOMMENDATION**: Review financial incentives and pricing mechanisms to support zero-emissions passenger and freight vehicles (e.g. subsidies, road-user pricing).

- **RELEVANT SECTORS**: Land freight.

## Improving Vehicles

**Absence of support for zero-emissions vehicles**

- **CURRENT DOMINANT STATE OF PLAY**: Absence of support for zero-emissions vehicles.

- **FUTURE POTENTIAL**: Active support for zero-emissions vehicles.

- **RECOMMENDATION**: Continue development and implementation of vehicle emissions standards and adoption of international best practice standards.

- **RELEVANT SECTORS**: Passenger, land freight.

**Absence of vehicle emissions standards in Australia**

- **CURRENT DOMINANT STATE OF PLAY**: Vehicle emissions standards implemented in line with international best practice.

- **FUTURE POTENTIAL**: Government and corporate vehicle fleets transition to electric fleets powered with renewable energy and invest in charging infrastructure, enabling broader uptake of electric vehicles.

- **RECOMMENDATION**: Build on and develop zero-emissions fleet strategies for government and corporate vehicle fleets (electric cars and public transport rolling stock).

- **RELEVANT SECTORS**: Passenger, land freight.

**Limited direction, trials, standards, and uptake in Australia of renewable-fuelled vehicles for freight, shipping and aviation**

- **CURRENT DOMINANT STATE OF PLAY**: Limited direction, trials, standards, and uptake in Australia of renewable-fuelled vehicles for freight, shipping and aviation.

- **FUTURE POTENTIAL**: Zero-emissions vehicles for freight, shipping and aviation are developed and rolled out where viable.

- **RECOMMENDATION**: Support research, commercialisation, and standards to support roll out of renewably-fuelled vehicles for freight, shipping and aviation.

- **RELEVANT SECTORS**: Land freight, aviation, shipping.

**Uncertainty about energy network impacts and infrastructure upgrades**

- **CURRENT DOMINANT STATE OF PLAY**: Energy networks prepared for increased demand and opportunities created by electrification of transport.

- **FUTURE POTENTIAL**: Plan for and manage integration of electric vehicles with Australia’s electricity networks building on existing collaborations.

- **RECOMMENDATION**: Develop national supply chain guidelines for electric vehicles and new technologies (e.g. battery components or renewable feedstocks for biofuels) and align to international initiatives.

- **RELEVANT SECTORS**: Passenger, land freight.
References

12. ibid, p. 270.
17. ibid.

20 The Conversation (2017) Why Gold Coast light rail was worth it (it’s about more than patronage), https://theconversation.com/why-gold-coast-light-rail-was-worth-it-its-about-more-than-patronage-78190


26 ibid, p. 9.


34 ibid, p. 38.


40 ibid.


46 New Yorker (2020) If We’re Bailing Out Corporations They Should Bail Out the Planet, www.newyorker.com/news/daily-comment/if-were-bailing-out-corporations-they-should-bail-out-the-planet


56 ibid, p. 22.


61 C40 Cities & ARUP (2016) Deadline 2020, https://cdn.locomotive.works/sites/5ab410c8a2f42204838f797e/content_entry5ab410fb74c4833febe6c81a/5ad4d6ae74c4837def5d3cde/files/Deadline_2020.pdf?1541690065
66 For more information on the Transport Decarbonisation Alliance, see: http://tda-mobility.org/
67 For more information on the EV100 initiative, see: https://www.theclimategroup.org/project/ev100
76 Transport Integration Act 2010 (Vic) Part 4 ‘Planning’, p. 55
77 Climate Change Act 2017 (Vic) Part 5 ‘Planning for climate change’, Division 3 ‘Emissions reduction pledges’, p.33
79 ibid, p.328.
80 Giles-Corti, B. et al., 2013. The influence of urban design on neighbourhood walking following residential relocation: Longitudinal results from the RESIDE study. Social Science & Medicine, 77(1), pp.20–30.
89 ibid, p.8


107 Ibid.


110 CleanTechnica (2020) UK Puts £3.4 Million Into Wireless Charging For Electric Taxis, https://cleantechnica.com/2020/02/06/uk-puts-3-4-million-into-wireless-charging-for-electric-taxis/


122 For more information, visit: https://fleets.chargetogether.org/


125 Infrastructure Victoria (2019) Advice on automated and zero emissions vehicles infrastructure, p. 117,
126 World Economic Forum (2019) How we can embrace the electrical vehicle transition by adopting smart charging, https://www.weforum.org/agenda/2019/05/how-charging-for-electricity-on-a-sliding-scale-could-power-the-electric-vehicle-transition


133 See more information at: https://bsc.org.au/


137 For more information, visit: https://www.weforum.org/global-battery-alliance/action.


147 For more information, see: https://www.gov.uk/government/publications/mode-shift-revenue-support-msrs-grant-scheme

148 For more information, see: https://www.welcomeuurope.com/european-funds/marco-polo-ii-461+361.html#tab=onglet_details


151 ibid, p.36.

152 The Conversation (2014) Too many loads on our roads when rail is the answer, https://theconversation.com/too-many-loads-on-our-roads-when-rail-is-the-answer-24118


162 Australian Government Bureau of Infrastructure, Transport and Regional Economics (2019) Australian


168 ibid.


178 Bureau of Infrastructure, Transport and Regional Economics (BITRE) (2014) Freightline 1 – Australian freight transport overview, Australian Government, Canberra


188 ibid, p.21


190 ibid.


201 For example, in 2016, 57 million Uber riders and drivers personal information was accessed by a hacker. See more: www.nytimes.com/2018/09/26/technology/uber-data-breach.html; and in 2020, freight delivery heavyweight Toll was hit by a cyber attack forcing the shut down of services to major retailers across Australia. See more: www.afr.com/technology/toll-faces-customer-fallout-after-cyber-attack-20200214-p540s2

202 State Government of Victoria Department of Premier and Cabinet (2019) Inquiry into the Victorian On-


Erhardt et al. (2019) Do transportation network companies decrease or increase congestion? Science
Advances, vol. 5(5), pp. 1-11, https://advances.sciencemag.org/content/5/5/eaau2670


249 ibid.
259 ibid.


ABOUT US
ClimateWorks Australia is an expert, independent adviser, committed to helping Australia, South East Asia and the Pacific region transition to net zero emissions by 2050.

It was co-founded through a partnership between Monash University and The Myer Foundation and works within the Monash Sustainable Development Institute.

ClimateWorks Australia, 2020,
*Moving to Zero: Accelerating the transition to zero-emissions transport.*

Published by ClimateWorks Australia
Melbourne, Victoria, June 2020
© ClimateWorks Australia 2020

For further information about *Moving to Zero* please contact:

**MICHAEL LI**
SENIOR PROJECT MANAGER
ClimateWorks Australia
michael.li@climateworksaustralia.org

**PETRA STOCK**
PROGRAM MANAGER
ClimateWorks Australia
petra.stock@climateworksaustralia.org

ClimateWorks Australia
Level 27, 35 Collins Street
Melbourne Victoria 3000

This work is subject to copyright. Apart from any use permitted under the Copyright Act 1968, no part may be reproduced by any process without written permission from the publisher.

This publication can be downloaded at:
www.climateworksaustralia.org

ClimateWorks Australia is an expert, independent adviser, committed to helping Australia and our region transition to net zero emissions. It was co-founded through a partnership between Monash University and The Myer Foundation and works within the Monash Sustainable Development Institute.