2022

FACTS

Framework for an Australian Clean Transport Strategy

Contents.

FACTS: A Framework for an Australian Clean Transport Strategy.

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Summary

An Australian transport decarbonisation strategy is critical to ensure everyday Australian households and businesses have more choice, pay less for transport, remain competitive, enjoy improved health outcomes, and can support the creation of Australian energy and related jobs.

Australia must take steps now to be able to capture these benefits and decarbonise all segments of transport to align with net zero by 2050 and interim emissions targets. The responsibility to achieve this outcome falls on all Australians. However, strong, consistent, and sustained government and industry action is required to enable this transition, and provide all Australians with clean transport options.

Targets

To assess the policies that will help us to reduce our transport emissions, and provide both transparency and accountability, we need clear decarbonisation targets for each transport segment which we can build on. We recommend the following targets:

Overarching decarbonisation targets

Net zero transport sector emissions by 2050 (at the latest)

Net zero land transport by 2045 (at the latest)

Light vehicle targets

A national target of 1 million zero emission light vehicles by 2027

State 2027 zero emission light vehicle targets QLD: 200k, NSW: 300k, VIC 275k, SA: 75k, WA: 100k, TAS: 25k, ACT: 20k, NT: 5k

55% zero emission light vehicle sales by 2030 (a fleet of 2-2.5 million vehicles)

100% zero emission light vehicle sales by 2035

100% zero emission light vehicle fleet by 2045

Government fleet targets

100% of new government vehicles to be 0g CO_2/km by 2023 – where fit-for-purpose models are available

100% of government fleet vehicles to be 0g CO_2/km by 2027 – where fit-for-purpose models are available

100% of service vehicles to be 0g CO_2/km by 2030 – where fit-for-purpose models are available

Domestic Aviation targets

20% fossil free domestic aviation by 2030

50% fossil free domestic aviation by 2035

Net zero domestic aviation by 2045

International Aviation targets

20% fossil free international aviation by 2035

50% fossil free international aviation by 2045

Net zero international aviation by 2050

Bus targets

No new urban diesel buses purchased from 2023 onwards

100% zero emission urban bus fleet by 2030

100% zero emission bus fleet (transit and coaches) by 2040

Mode share shift targets

50% active and public transport commuting share by 2035

Heavy truck targets

100% zero emission heavy truck sales by 2035

100% zero emission heavy truck fleet by 2045

Urban truck target

100% zero emission urban truck fleet by 2035

Shipping targets

50% emissions reduction in shipping by 2040

Net zero shipping by 2050

Rail target

100% net zero emission rail fleet by 2045

Ferry targets

100% of government supported ferry fleets to be fossil free by 2035

100% net zero emission ferry fleet by 2050

Policies to accelerate the transition

This report details suggested policies that support the transition to net-zero emissions transport and ensure a liveable future in Australia. There is a policy checklist for each level of government included below.

Local government checklist

Local government action is critical to addressing transport emissions in our cities and local regions.

Set net zero and interim decarbonisation targets for each transport segment

- Encourage remote work
- Introduce anti-idling initiatives
- Invest in active transport networks
- Support electric micro-mobility
- Support car-sharing
- Parking reform
- Introduce low emissions zones (LEZs)
- Support road pricing reform
- Improve public transport networks
- Improve investment decision making
- Set an airport 2030 decarbonisation target
- Introduce a low-carbon ports initiative
- Provide zero emission fleet support
- Reform building policy
- Fund urban charging
- Electrify taxis and ride-share fleets
- Trial and support zero emission ferries
- Reduce avoidable travel
- Introduce zero emission heavy vehicle fleet support
- Fund a national charging network
- Consider virtual international conferences
- Consider freight choices

State / territory government checklist

State and territory governments can work together to move past the current patch-work approach and strive to help Australian households and businesses to make the most of the transport transition and ensure Australia stays connected.

Set net zero and interim decarbonisation targets for each transport segment

- Encourage remote work
- Introduce anti-idling initiatives
- Support Mobility-as-a-Service (MaaS)
- Invest in active transport networks
- Support electric micro-mobility
- Parking reform
- Introduce low emissions zones (LEZs)
- Support road pricing reform
- Improve public transport networks
- Improve investment decision making
- Introduce a zero emission vehicle sales mandate
- Provide zero emission fleet support
- Reform building policy
- Introduce emissions stickers
- Fund urban charging
- Enhance grid utilisation and renewable energy uptake
- Develop an EV database
- Initiate an EV charging infrastructure register
- Support charging infrastructure planning
- Electrify taxis and ride-share fleets
- Trial and support zero emission ferries
- Reduce avoidable travel
- Introduce a zero emission heavy vehicle sales mandate
- Introduce a zero emission heavy vehicle fleet support
- Introduce zero emission heavy vehicle curfew exemptions
- Fund a national charging network
- Support electric and hydrogen aviation trials
- Consider virtual international conferences
- Support traffic management
- Consider freight choices
- Fund strategic green hydrogen clusters
- Set strategic direction for Sustainable Aviation Fuels
- Set an airport 2030 decarbonisation target
- Introduce a low-carbon ports initiative
- Enhance Australia's critical minerals strategies
- Incentivise local component production & vehicle manufacturing
- Incentivise local component recycling
- Invest in local skills development
- Support new technology pilot projects

Federal government checklist

The Australian federal government has an essential role to play to ensure the nation captures the significant economic opportunities that decarbonised transport can offer and ensure we remain competitive with our global peers.

- **Set net zero and interim decarbonisation targets for each transport segment**
- Encourage remote work
- Introduce anti-idling initiatives
- Invest in active transport networks
- Support electric micro-mobility
- Introduce low emissions zones (LEZs)
- Road pricing reform
- Improve public transport networks
- Improve investment decision making
- Introduce a zero emission vehicle sales mandate
- Provide zero emission fleet support
- Introduce a zero emission vehicle incentive scheme
- Introduce a zero emission vehicle company tax benefit
- Reform building policy
- Provide consumer support
- Enhance grid utilisation and renewable energy uptake
- Develop an EV database
- Initiate an EV charging infrastructure register
- Support charging infrastructure planning
- Transition to World Harmonised Light Vehicle Testing Procedure (WLTP)
- Introduce a zero emission heavy vehicle sales mandate
- Introduce a zero emission heavy vehicle fleet support
- Introduce zero emission heavy vehicle company tax benefits
- Introduce zero emission heavy vehicle design rule exemptions
- Fund a national charging network
- Support zero emission aviation trials
- Support new technology pilot projects
- Consider virtual international conferences
- Support traffic management
- Introduce carbon pricing
- Consider freight choices
- Fund strategic green hydrogen clusters
- Set strategic direction for Sustainable Aviation Fuels
- Include international aviation and shipping in national targets
- Set an airport 2030 decarbonisation target
- Introduce a low-carbon ports initiative
- International transport R&D
- Develop net zero plans for shipping and aviation
- Electrify taxis and ride-share fleets
- Trial and support zero emission ferries
- Consider a future scrappage scheme
- Reduce avoidable travel
- Consider air-travel alternatives
- Enhance Australia's critical minerals strategies
- Incentivise local component production and vehicle manufacturing
- Incentivise local component recycling
- Invest in local skills development
- Retrofit support

What you can do?

Australia is in the fortunate position of having many options available to us on our journey to net zero transport. But these opportunities will not last forever.

This document is a call to action for Australian governments and industry to consider and incorporate our policy recommendations, in support of achieving the decarbonised transport targets outlined in this strategy.

This is also a call to all Australians to contact your local, state/territory and federal representatives, share the Transport FACTS with them, and outline what you think they should do to support the decarbonisation of transport in Australia.

What is FACTS?

FACTS: a Framework for an Australian Clean Transport Strategy has been developed to enable and boost cooperative action across federal, state, territory, and local governments in Australia, together with industry, to support the decarbonisation of the transport sector, and in turn, the uptake of low and zero emission transport technologies and strategies.

While individual governments have taken some steps forward on decarbonising transport, we have not yet seen the level of policy ambition that is required for Australia to achieve a net zero emissions target by 2050 and support intermediate emission reduction goals.

Governments have sought the advice of experts to manage and deal with the COVID pandemic to great effect. It is now time to similarly draw on the expertise of our many transport and energy scientists, engineers, planners, and economists to inform the development of a serious emissions reduction strategy for Australia's transport system.

By joining our international trading partners in their transport decarbonisation efforts, and altering course towards a rapid emissions reduction trajectory, Australia will be able to capture the major job creation and economic development opportunities that the transition to a decarbonised transport sector can deliver.

Our aims

The primary objective of FACTS is to provide a positive contribution to the public discussion on transport decarbonisation, offering an expert lens on how Australia can contribute to global efforts to avoid the worst potential consequences of climate change. Our key aims are to:

1. Advocate for Australian action on transport decarbonisation in the global transition to a net zero economy

2. Highlight key transition considerations for the transport sector

3. Outline decarbonisation targets as a starting point for transitioning the transport sector

4. Provide expert policy suggestions to local, state/territory, and federal governments, as well as industry, on how to achieve these transport decarbonisation targets.

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Our policy principles

A holistic approach to decarbonisation

The pervasive nature of fossil fuel use and carbon emissions throughout society requires a holistic view on how to reduce emissions across the entire transport system, while supporting broader economy decarbonisation within the narrow time frames available. Our recommendations account for the potential interactions of transport decarbonisation on other sectors of the economy, particularly the energy sector.

Setting both near-term and medium-term transport targets

We have set clear near-term and medium-term targets as a starting point for providing accountability for transport decarbonisation policies to be assessed and tracked against. Targets are a useful signal to consumers, industry, and other international markets that we have set a pathway to net zero and allow us to demonstrate our position moving forward.

Consideration of a broad range of decarbonisation strategies and technology options

We consider a wide range of strategies and technology options for decarbonising Australia's transport system.

These options are classified under the **AVOID-SHIFT-IMPROVE** framework:

AVOID – leading to fewer / shorter trips via alternatives to physical travel (e.g. telecommuting), and reduction of trip lengths.

SHIFT – encouraging the transport of people and goods to be carried out through more efficient modes.

IMPROVE – transitioning to low, and ideally zero emission powertrain options across land, sea and air transport.

Differing responsibility across levels of government and industry

We delegate transport decarbonisation responsibilities across all three levels of Australian governments and industry.

We need to move away from the current patch-work approach, towards a clear roadmap for Australia. A coordinated vision for a decarbonised transport system can help to accelerate the transition to net zero transport, while bolstering community confidence.

[1] *Sourced from www.bitre.gov.au/sites/default/files/documents/bitre_aus_infrastructure_yearbook_2020.pdf, taking account of on-road fuel excise after credits ($11.6B at ~40 cents per litre), assuming an average fuel cost of $1.35 and a 10% margin for local retailers ($1.20). Resulting in total on-road fuel spending in the order of $40B p.a.; does not consider non-road, construction, shipping, and aviation fuel spending.*

Capturing the economic, social, and environmental bene its

Our recommended policies aim to advance Australia's productivity, future job market, and economic development, while providing a better future for Australians through improved social, health and economic outcomes. Some key differences between a fossil fuel dependent transport future and a clean transport future are highlighted below.

A fossil fuel dependent transport future	VS	A clean transport future
Incompatible with a 2050 net zero target	→	Supports a 2050 net zero target
Local jobs at risk from policy inaction	→	Supports workforce transition + local job creation
Lack of supply of low/zero emission vehicles	→	Clear targets to guide policy + increase supply
No national plan for future road taxation	→	Transition plan for road taxation
Challenges integrating renewables	→	Supports grid stability and renewables uptake
Continuing foreign fuel dependence resulting in >$30B[1] p.a. leaving Australia	→	>$30B p.a. in combined savings & spending in the local economy
Increased national security risk	→	Reduced foreign fuel dependence
Australians paying high transport costs	→	Reduced costs for moving people + goods
Premature deaths due to transport air pollution	→	Reduced air pollution + improved public health
Lost opportunity on critical mineral exports	→	Mining transition to support future prosperity

Setting the scene

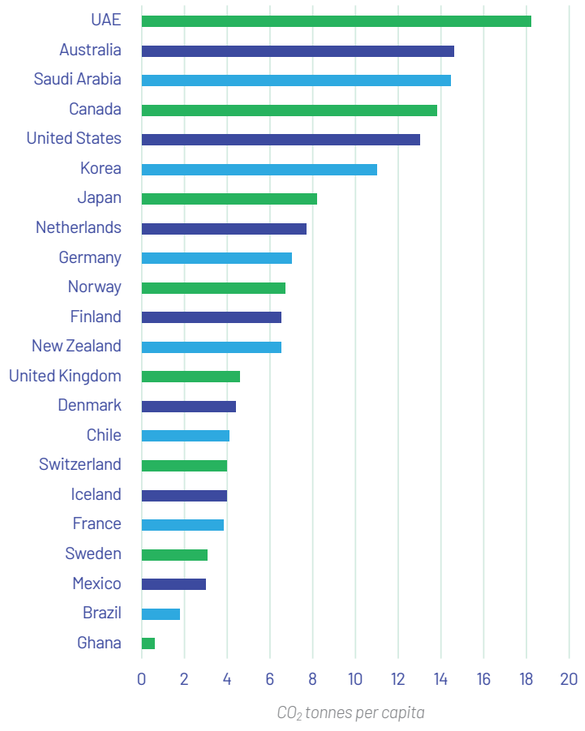
Our existence is under threat globally

All pathways consistent with limiting global warming to 1.5°C require a rapid reduction of carbon emissions, reaching net zero globally around 2050. Without immediate, rapid, and large-scale reductions in emissions we are likely to overshoot this target, increasing the chances of more severe climate changes impacts (IPCC, 2021).

We need to meet our responsibilities

As a developed nation, Australia has a responsibility to make faster progress, reflecting our greater contribution to past emissions, our ability to act quicker as a high-income nation, and given we are one of the largest emitters per capita globally (see Figure 1).

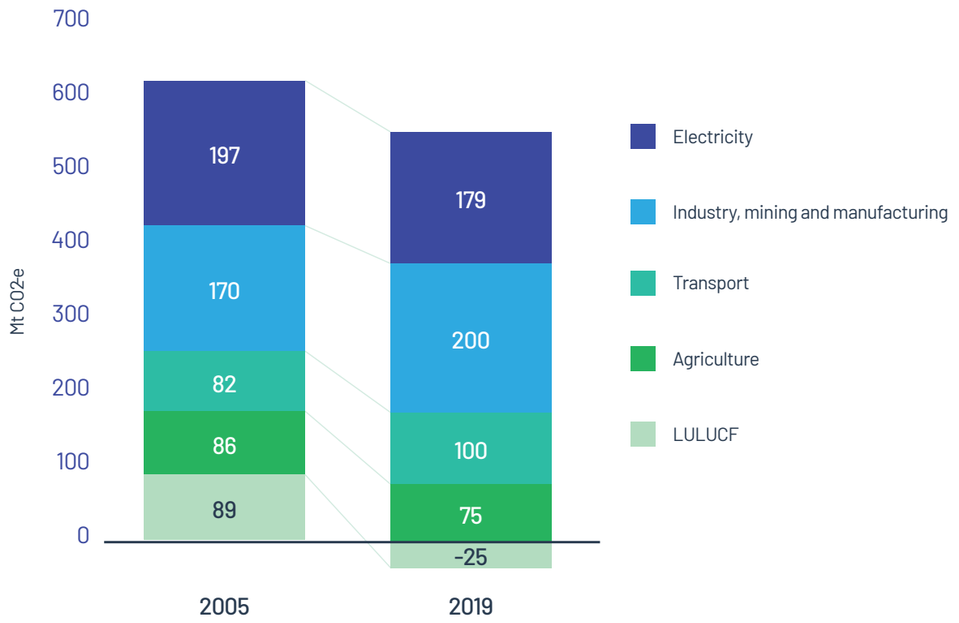
Figure 1.
Carbon emissions from fuel combustion per capita for select countries (IEA, 2020c)



Current efforts are insufficient

According to the National Greenhouse Gas Inventory, Australia slightly reduced domestic emissions between 2005 and 2019, as shown in Figure 2, this is largely due to the counting of land-use, land-use change and forestry (LULUCF) reductions. Excluding this sector, Australia's emissions have actually increased by almost 4%, with emissions from industry, mining, manufacturing and transport increasing by 19% (Commonwealth of Australia, 2021a).

Figure 2.
Reported change in emissions by sector: 2005 - 2019 in Mt CO_2-e (Commonwealth of Australia, 2021a).



Australia needs raised ambition for 2030

Our current 2030 emissions reduction target of between 26-28% (Commonwealth of Australia, 2020, 2021c) is out of step with our international partners and will lead to a more costly emissions reduction pathway.

The International Energy Agency's NZE2050 scenario suggests that a 45% reduction in total global carbon emissions is required by 2030 for a 50% chance of limiting global temperatures below 1.5°C (IEA, 2020e).

In line with this, many countries are committing to emissions reduction targets twice as ambitious as Australia's. This includes the UK (68% by 2030), EU (55% by 2030), and US (52% by 2030) (Slezak, 2021).

When considering emissions reduction trajectories, cumulative impacts are important. A recent report from the Australian Climate Panel (Steffen et al., 2021) found:

1. Emissions would need to reduce by 50% on 2005 levels by 2030 to stay within a 2°C carbon budget, and 74% on 2005 levels by 2030 for a 1.5°C carbon budget.
2. Under the current 2030 target, for Australia to meet its 2°C climate budget it would require 10 times the abatement per annum compared to current levels.

What about net zero?

Countries responsible for around 60% of global energy-related carbon emissions have announced net zero emissions targets (IEA, 2020). The Australian Government has now also committed to a 2050 net zero target (Commonwealth of Australia, 2021a). Despite this, The Climate Targets Panel suggests that to stay within our 2°C and 1.5°C carbon budgets, a 2045 and 2035 timeframe would be required to achieve net zero emissions (Steffen et al., 2021).

While it is a positive move that Australia has now committed to net zero by 2050, without a change in the nation's 2030 target this will lead to:

1. **a more challenging and costly emission reduction pathway** and
2. **inconsistency with our Paris commitments, with our carbon budget potentially exceeded by 2034 under the current approach** (Steffen et al., 2021).

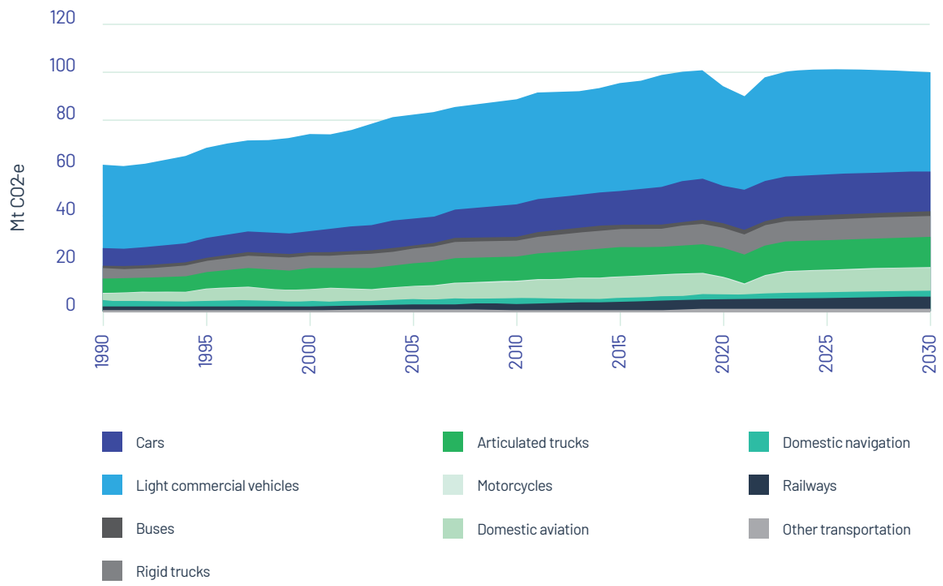
Every Australian state / territory government has also committed to a net zero target, however, policy efforts will need to be significantly increased to support the achievement of these targets, particularly prior to 2030.

To meet net zero we must reduce our increasing transport emissions

Australia's transport sector is one of the most emission intensive sectors (~17.5% of domestic emissions in 2021), with emissions forecast to increase until at least 2030 (at 100 Mt CO_2-e p.a.) – see Figure 3 (Commonwealth of Australia, 2020).

Based on Australia's current emission reduction targets, this would mean that transport would represent around a quarter of the country's domestic emissions by 2030, with up to 15% of domestic emissions coming solely from light vehicles (cars and light commercial vehicles).

Figure 3.
Historical and projected transport emissions by mode (Commonwealth of Australia, 2020).



We need a clear vision, starting with strong transport decarbonisation targets

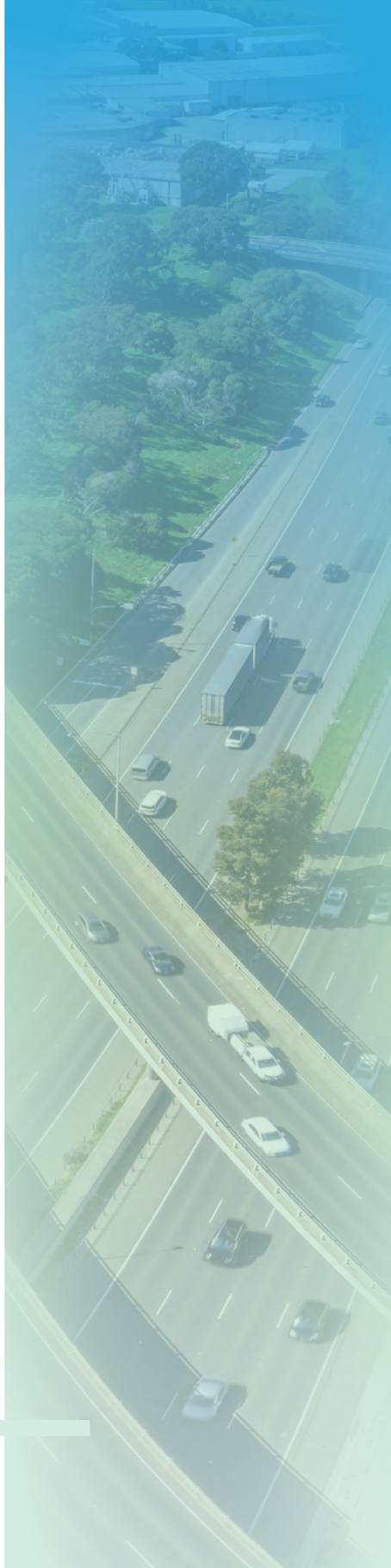
There is limited time to achieve significant emission reductions. Australia must set a clear vision for rapid transport sector decarbonisation and invest in the development of transformative technologies that will enable all countries to limit climate change impacts. To achieve this, FACTS recommends a target of net zero transport sector emissions by 2050.

More difficult-to-decarbonise transport segments, such as shipping and aviation, will require more time to develop and deploy strategies and actions for Australia to achieve net zero transport emissions by 2050 and to minimise the requirement to offset remaining emissions.

Target:
Net zero transport sector emissions by 2050 (at the latest)

Land transport not only makes up the majority of Australia's growing transport emissions but it also offers the best opportunity to contribute quickly and significantly to reducing emissions. To do this requires our commitments to match those of our international partners. That's why FACTS is strongly advocating that all levels of government, together with industry, commit to net zero land transport emissions by 2045 at the latest.

Target:
Net zero land transport emissions by 2045 (at the latest)



A strategic transition to maximise the benefits for Australia

The transition can deliver significant net benefits

Transitioning the transport sector to cleaner alternatives is inevitable, given the economic, social, and environmental benefits that this transformation can deliver. However, we must accelerate this shift to meet climate targets. This requires ambitious policy action and funding.

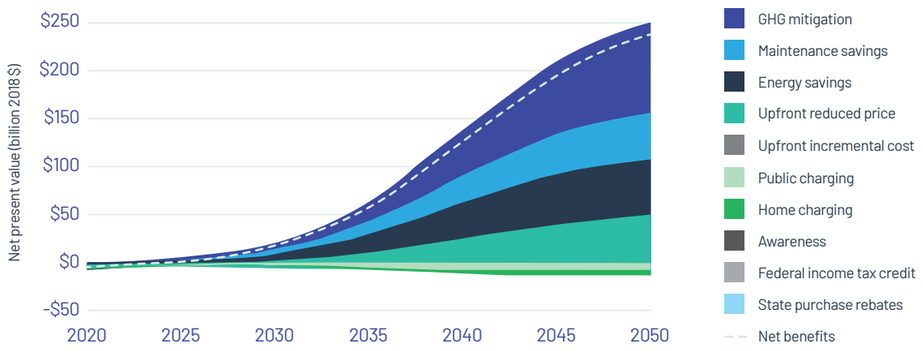
A report by the Australian Conservation Foundation (2021) found that maintaining Australia's current approach to managing transport emissions could cost up $865 billion between 2022 and 2050. These costs were attributed to air pollution ($488 billion), greenhouse gas emissions ($205 billion), noise ($95 billion), and water pollution ($76 billion).

In contrast, by adopting more ambitious zero emission transport policies, we could achieve a significant reduction in these costs, up to $492 billion (NPV 2021) (Australian Conservation Foundation, 2021).

As further evidence of the net benefits of taking immediate action, the International Council on Clean Transportation (ICCT) found that the benefits of supporting electric vehicle adoption prior to 2030 outweighs the upfront costs by a factor of 5 to 11 – see Figure 4 for an example of net benefits estimated for the US.

Of note to the Australian context is that the ICCT analysis excluded consideration of the broader economic benefits stemming from local transport energy production (electricity), as well as wider economic development opportunities through increased demand for critical minerals. These factors further increase the potential net benefits, and underline why the decarbonisation of transport globally presents substantial economic opportunities for Australia.

Figure 4.
Net present value of the costs and benefits of transitioning to EVs in the US: 2020-2050 (ICCT, 2019)



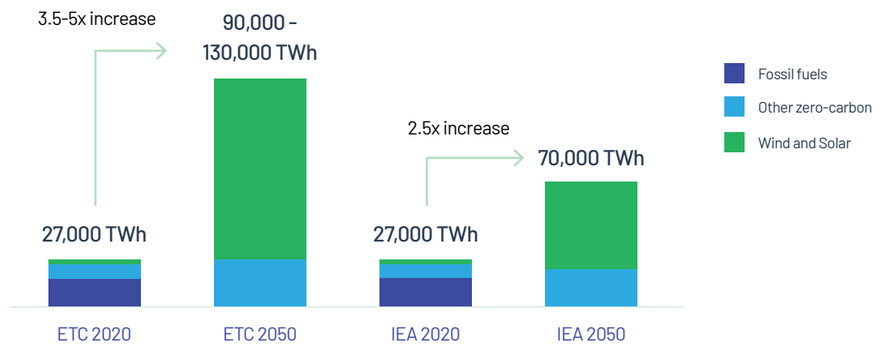
How we transition is important

1. A clean transport future will require increased renewable energy generation, with significantly more required for green hydrogen, ammonia, and synthetic fuels

In order to limit global warming to 1.5°C it is estimated that up to two-thirds of the global final energy share will need to be met through direct electrification, and a further 10% to 15% will need to be met through indirect electrification e.g., hydrogen, ammonia, etc. To achieve this, the increase in electricity generation required is in the order of 2.5 to 5 times current electricity generation and will need to be sourced predominately from renewables (ETC, 2021a; IEA, 2020b) – see Figure 5.

Given green (renewable) hydrogen and hydrogen-derived fuels consume 2 to 14 times more electricity than direct electrification (Ueckerdt et al., 2021), if the proportion of hydrogen was to increase beyond 15%, this would dictate the need for an even greater investment in electricity generation, beyond the unprecedented increases already required under a relatively energy-efficient, electrification-dominated decarbonisation pathway (ETC, 2020a).

Figure 5.
Projected change in global electricity generation between 2020 and 2050 | ETC and IEA net zero emission scenarios. (Whitehead et al., 2021)



2. The entire economy needs to transition, and green hydrogen/hydrogen-derived fuels are crucial for harder-to abate sectors

Although transport decarbonisation is possible via different energy carriers, including electricity, hydrogen, biofuels, and synthetic fuels, some sectors will be more reliant on specific energy carriers to decarbonise.

Green hydrogen is expected to be critical for decarbonising heavy industry, including: steel, aluminium, fertilisers, cement, and chemical feedstocks. Green hydrogen and hydrogen-derived fuels, such as ammonia and synthetic jet fuel, will be required to support the decarbonisation of shipping and aviation (ETC, 2020a, 2021b; IEA, 2021d).

The future decarbonisation of the global economy is dependent on the strategic application of energy carriers where each can deliver the greatest emissions reductions, at the lowest cost. Figure 6 provides an example of this spectrum of prioritisation for green hydrogen / hydrogen-derived fuels.

Without this prioritisation, there is likely to be avoidable increases in energy demand, land use impacts, and overall costs, which could significantly jeopardise the likelihood of achieving net zero by 2050, while leading to investment in stranded assets and the inefficient use of taxpayer funds (ETC, 2020a, 2021b; IEA, 2021d; Whitehead et al., 2022).

Figure 6.
Example of spectrum of potential green hydrogen / hydrogen-derived fuel applications from unavoidable to uncompetitive. Source: Whitehead et al. (2022). Concept credit: Liebreich Associates (2021).

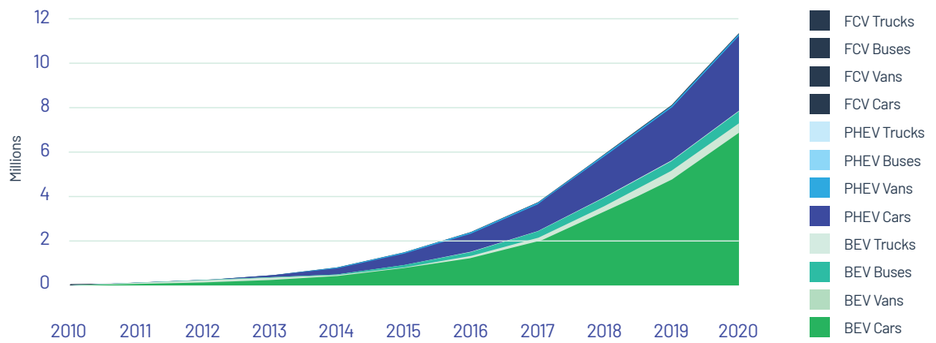
Unavoidable ↑ Uncompetitive

Fertiliser	Hydrogenation	Hydrocracking	Desulphurisation
Steel	Chemical feedstock	Methanol	Shipping / long-haul aviation*
High temp. industrial heat	Long-term energy storage	Short / medium-haul aviation	Long-haul trucks, buses, trains
Low/mid temp. industrial heat	Local ferries	Commercial heating	Domestic heating
Light duty vehicles	Short / medium-haul trucks, buses, trains	Bulk e-fuels	Power system balancing

3. Market maturity

The market share of electrified powertrains has been increasing in international markets, particularly in the light duty vehicle sector. This trend is expected to continue as battery prices rapidly fall, contributing to price parity being reached with fossil fuel vehicles by the mid-2020's (BloombergNEF, 2020; ETC, 2020a). The adoption of electrified powertrains has been supported by strong international policy, including proposed bans on the sale of new fossil fuel vehicles, vehicle manufacturer commitments to increase electric vehicle sales, regulatory sales mandates and fuel efficiency standards

Figure 7.
Global stock of low and zero emission vehicles (IEA, 2021a)



Hydrogen fuel cell vehicles are less mature in terms of market development, and as a result have a lower market share. It is anticipated that hydrogen fuel cell vehicles may play a role in heavy-duty land transport after 2030 - if the technology matures and becomes cost-competitive. Fuel cell durability, fuel cell costs and green hydrogen fuel costs, all will need to improve significantly, and this will be weighed against continuing improvements in battery-electric technology for these same applications (ETC, 2021b; IEA, 2020a; U.S. DoE, 2019).

Green hydrogen, hydrogen-derived fuels (ammonia, synthetic fuels), and biofuels will play a more important role in reducing emissions from the long-haul shipping and aviation sectors. The high energy requirements of these applications, and high vehicle costs, mean that drop-in fuels will be crucial for reaching net zero emissions by 2050 (ETC, 2021b; IEA, 2020a; U.S. DoE, 2019). Significant reductions in the cost of green hydrogen and biofuels, combined with increases in the costs of conventional fossil fuels, will be necessary for supporting the decarbonisation of these more challenging transport segments.

What does this all mean for Australia?

Australia should aim to electrify as much as possible

As the most energy-efficient pathway to decarbonisation, Australia should aim to electrify as much as possible of the national economy, including transport (Rewiring Australia, 2021). While this is expected to require significant increases in electricity generation, specifically renewable energy, it will be substantially less than what would be required under scenarios that rely more heavily on green hydrogen, hydrogen-derived fuels and biofuels (ETC, 2020b).

While all energy carriers have important roles to play in the transport sector, strategic investment is required to support priority applications, to reduce emissions at the lowest cost and with the lowest impact on energy demand and land use. The priority of different energy carriers across transport applications can be represented on a spectrum, as illustrated in Figure 8.

Figure 8.
Priority use of different energy carriers

Australia should target strategic green hydrogen production

For Australia to have the greatest chance of capturing the potential economic benefits stemming from local green hydrogen production and applications, governments should focus near-term support on production and end use cases around hydrogen clusters. These clusters are best located at ports and airports, where several end users could be co-located, while being available to directly export overseas – if an international market emerges.

It is important that green hydrogen investment is targeted to ensure it delivers real outcomes for the nation and builds capacity across the entire value chain. This strategic approach is critical to enabling green hydrogen to become a viable energy carrier.

We recommend efforts are focussed on green hydrogen production in order to align with achieving net zero emissions by 2050; although there may be some minor uses of methane-hydrogen paired with carbon capture and storage (ETC, 2020b).

Figure 9.
Strategic applications of hydrogen/hydrogen-derivatives at ports

CASE STUDY

Hydrogen is a critical feedstock for heavy industries which are unable to be directly electrified with renewable energy. Rather, this renewable energy can be used to produce green hydrogen (via electrolysis) which can be used in place of existing fossil fuels, including Brown or Grey Hydrogen (which is produced with coal and gas). With renewable energy costs falling, this technology is becoming increasingly commercially viable.

One great example of the use of green hydrogen is its application in the development of the world's first "green" steel produced by a Swedish steel company, replacing traditional coking coal. This green steel is being used to manufacture trucks for Volvo, with commercial quantities expected to be produced by 2026.

Image: Green hydrogen plant in Japan

A clean transport strategy that benefits Australia

A Framework for an Australian Clean Transport Strategy (FACTS) has been designed to:

1. Consider the composition of the transport system and its fundamental purpose

Transport is about moving people and goods to improve quality of life and provide freedom

- These movements occur within cities and regions
- These movements occur between cities and regions
- These movements also occur in and out of Australia

As such, FACTS accounts for these different types of movements, occurring at different geographical levels.

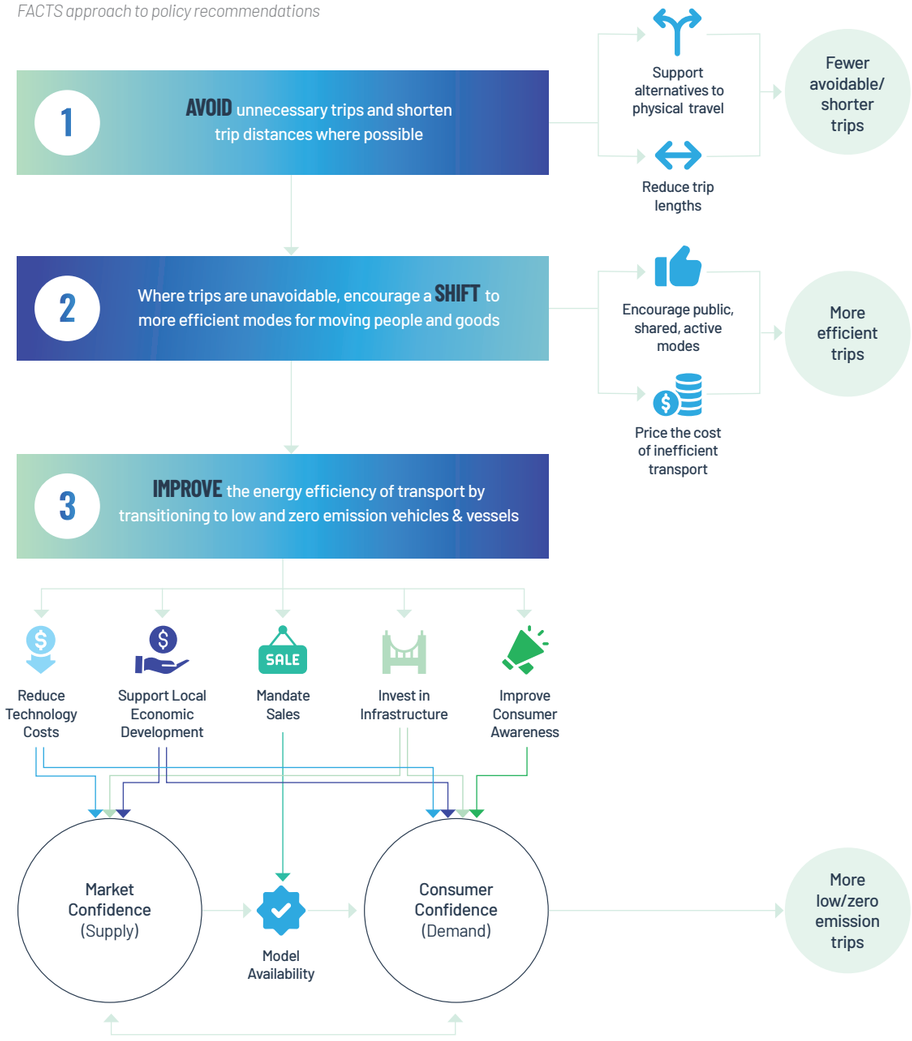
2. Include the development of a comprehensive policy package

No single policy in of itself can decarbonise the entire transport sector. It is critical that governments adopt a comprehensive suite of policies to accelerate emissions reductions as quickly as possible across all transport segments.

FACTS considers policies within the AVOID – SHIFT – IMPROVE framework (Deutsche Geselschaft, 2019) to not only outline the clear technological transitions required, but also the demand and behaviour change strategies that will play an important role in reducing transport emissions (see Figure 10).

While individual policies can have marginal impacts, it is the combination of strong, and sustained policies that will be required to align Australia's transport emissions reductions with a net zero target, and lead to fewer avoidable trips and/or shorter trips, more efficient trips, and more low/zero emission vehicle trips (Wolinetz & Axsen, 2017).

Figure 10.
FACTS approach to policy recommendations



3. Clearly identify which stakeholder(s) are best positioned to implement each policy

It is critical that the package of policy recommendations proposed in FACTS are deployed by those stakeholders best positioned to support the change, including all levels of government, and industry.

Responsibility:

Local government:	State government:	Federal government:	Industry:

4. **Include specific reference to not only powertrains, but also fuel sources and energy carriers,** to ensure:

- Only technologies which enable Australia to meet net zero targets are supported
- Economy-wide decarbonisation synergies are considered as part of the decarbonisation of transport
- International consistency to ensure efficient allocation of investments in line with global trends.

5. **Aim to electrify as much as possible,** with green hydrogen and other low-carbon energy carriers (e.g., sustainable aviation fuels) used to achieve decarbonisation in more difficult to decarbonise transport segments.

Figure 11.
LZEV technologies considered across transport segments

LZEV technologies considered across transport segments	Category	Transport Segment							
		Light-duty land vehicles				Heavy-duty land vehicles		Shipping	Aviation
		Micro-mobility	Light vehicle	Urban buses	Urban trucks	Long-haul buses	Long-haul trucks		
Battery Electric, including plug-in hybrids	Zero Emission	✓	✓	✓	✓	✓	✓	✓	✓
Hydrogen Fuel Cell	Zero Emission					✓	✓	✓	✓
Hydrogen/Ammonia Combuston Engine	Low Emission							✓	✓
Hydrogen-based Synthetic Fuel Combustion Engine	Low Emission								✓
Biofuel Combustion Engine	Low Emission					✓	✓	✓	✓

6. **Prioritise necessary energy investment to ensure that all transport fuel sources and energy carriers are produced using low-carbon renewable energy,** noting the significant increases in electricity generation required even under the most energy-efficient pathway to decarbonisation - mainly via direct electrification i.e. electric vehicles.

7. **Adopt the following definition for low and zero emission vehicles:**[2]

Light duty transport

(micro mobility, cars, light commercial vehicles, trams, urban buses, and urban trucks)

- **Low emission vehicle (LEV):** tailpipe emissions less than 50 grams CO_2 per kilometre
- **Zero emission vehicle (ZEV):** tailpipe emissions 0 grams CO_2 per kilometre

Heavy duty transport

(long-haul buses, long-haul trucks, ferries, trains, ships, planes)

- **Low emission vehicle (LEV):** combustion engine running on hydrogen, hydrogen-derivatives (ammonia, synthetic fuels), sustainable biofuels
- **Zero emission vehicle (ZEV):** electrified powertrain running on electricity and / or hydrogen (via fuel cell)

8. **Consider the timing of policy recommendations**

FACTS not only considers short-term policies required immediately to kick-start the decarbonisation of Australia's transport system, but also the medium-to-long term actions that will be critical to delivering sustained emissions reductions over the next 25-30 years. The timing of policy recommendations has been informed by considering the current market conditions, availability of technological options, and overall feasibility.

Time scale:

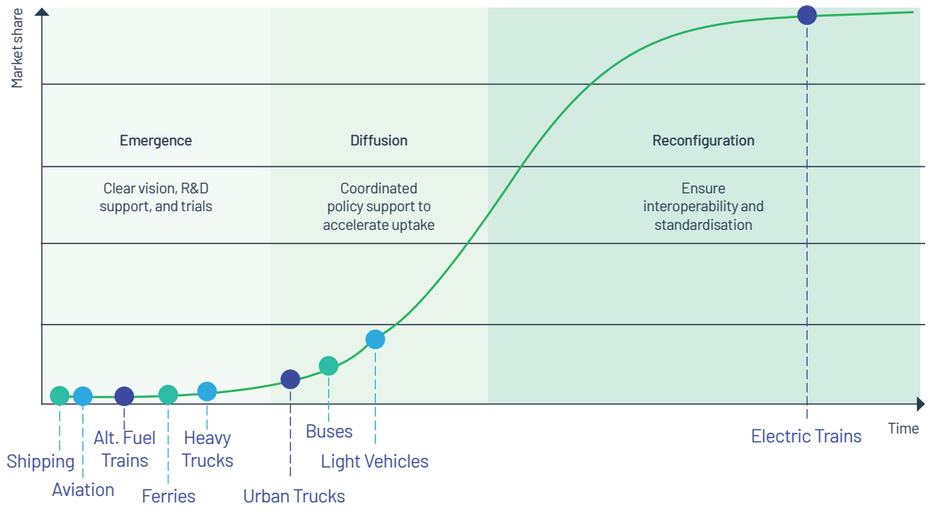
Short term (ASAP):	Medium term (before 2035):	Long term (after 2035):

Different transport segments currently have low/zero emission options at varying stages of maturity and uptake. Figure 12 illustrates where technology indicatively sits in the Australian context. Electrified trains are the most mature technology, widely available internationally, and primarily limited by the ability and/or costs to install overhead electricity infrastructure. Light vehicles, followed by urban buses and urban trucks, have relatively mature zero emission alternatives in the form of electric vehicles. Heavy trucks, ferries, alternative-fuel trains, and short / medium-haul aviation have fewer mature options but trials of both electric and hydrogen variants are underway, with mature options likely to emerge in the next decade. Finally, long-haul shipping and international aviation are the most immature, and the most difficult to decarbonise – necessitating the need for strong strategic direction, as well as research and development support.

[2] *The following limits are under the World harmonised Light vehicle Testing Procedure (WLTP) that we recommend Australia adopts.*

Figure 12.

Indicative Australian stages of transition of different transport modes (based on Victor et al. (2019)).



The recommendations outlined in FACTS consider how policies focussed on low and zero emission technologies can support quick wins for transport decarbonisation in the short-term, while laying the groundwork for future innovations in those harder-to-decarbonise segments.

1.

Diffusion technology - quick wins for transport decarbonisation

Australia should support accelerated adoption of maturing technologies and sales targets prior to 2030.

- Cars
- Light Commercial Vehicles
- Trams
- Urban Buses
- Urban Trucks
- Electrified Trains

2.

Medium-term emerging technology - with support, can decarbonise

Australia should support early efforts via trials and set-out a plan to decarbonise prior to 2040.

- Long-haul Buses
- Long-haul Trucks
- Ferries
- Non-electrified Trains
- Domestic Aviation

3.

Long-term emergence technology - requires strong plan to improve

Australia should create an actionable plan for decarbonisation, with ambitious strategies to decarbonise prior to 2050 and minimise need for carbon offsetting.

- International Shipping and Aviation

9. Setting targets for Australia

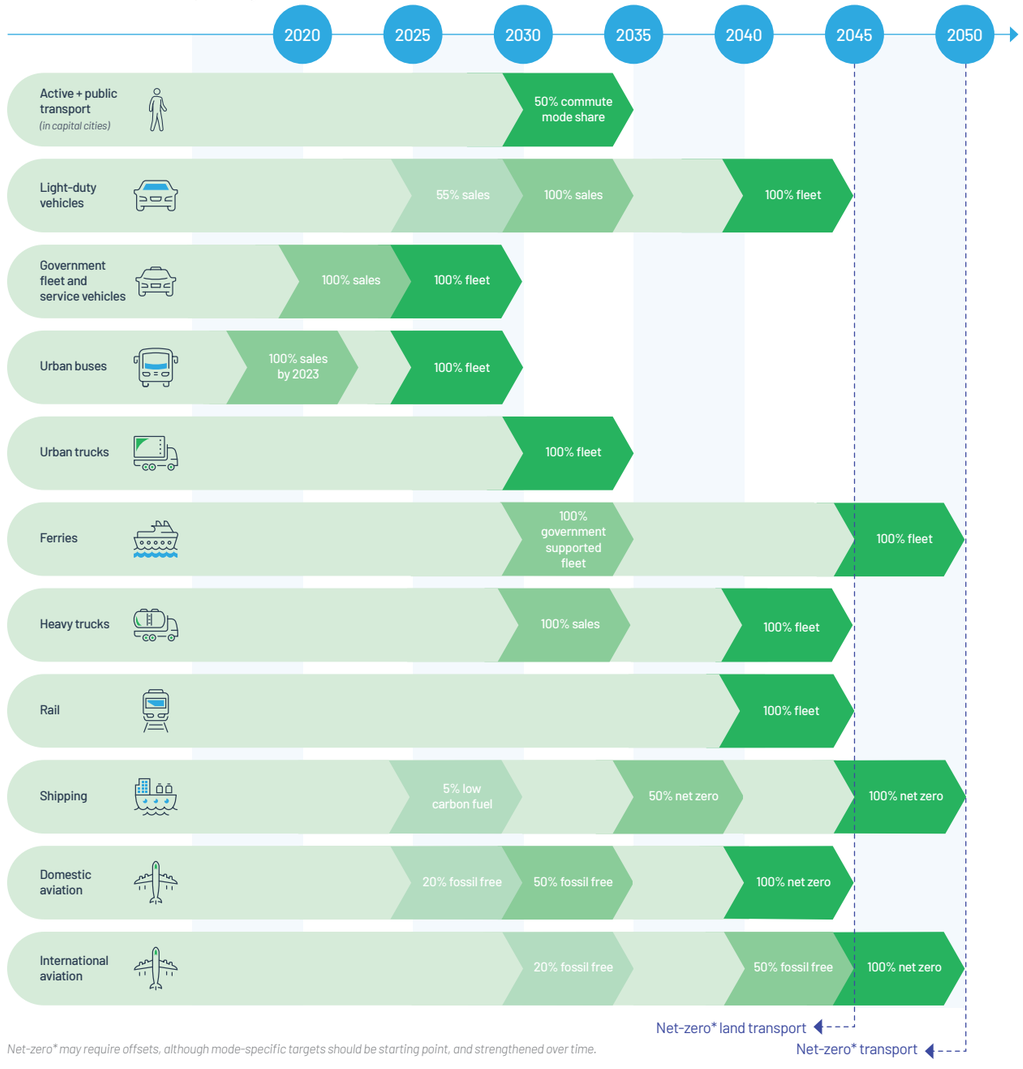
Internationally, decarbonisation targets have been a popular policy mechanism for signalling to the market the end of fossil fuel-powered transport, while enabling policy efforts to be linked to, and accountable against these targets.

Here we have set indicative targets for decarbonising different segments of Australia's transport system, as a starting point for governments and industry when designing appropriate policy mechanisms. While these targets are broadly consistent with global efforts to achieve net zero emissions by 2050, and developed based on the current status of each transport segment, detailed modelling may be required to further refine these targets.

In our view, these targets should be introduced as soon as possible to set a clear vision for the future of clean transport in Australia. They are included in call-out boxes throughout the FACTS recommendations, and are summarised below.

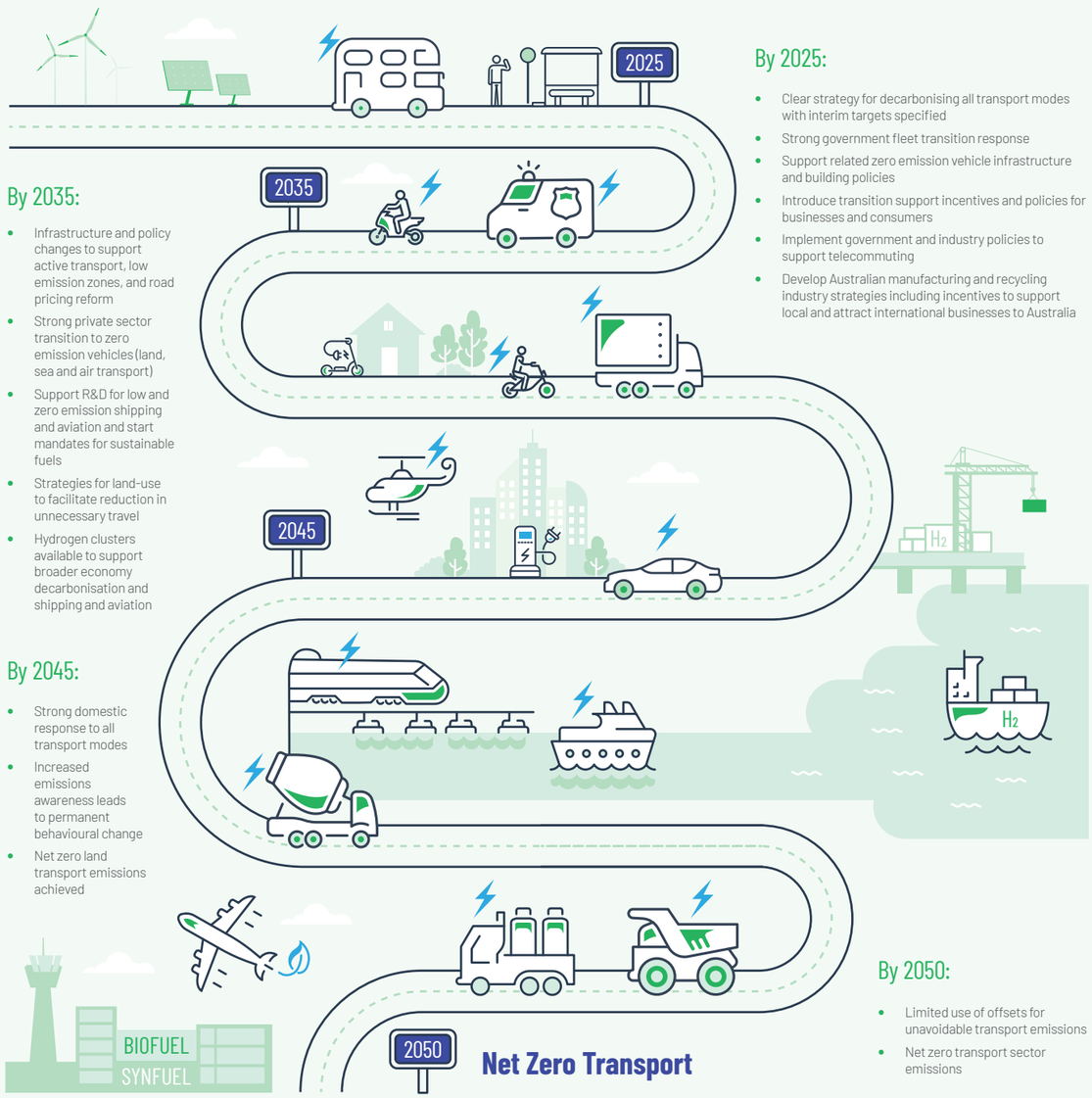
Figure 13.

Recommended Clean Transport Targets



Net-zero may require offsets, although mode-specific targets should be starting point, and strengthened over time.*

A pathway to a net zero transport future for Australia



By 2035:

- Infrastructure and policy changes to support active transport, low emission zones, and road pricing reform
- Strong private sector transition to zero emission vehicles (land, sea and air transport)
- Support R&D for low and zero emission shipping and aviation and start mandates for sustainable fuels
- Strategies for land-use to facilitate reduction in unnecessary travel
- Hydrogen clusters available to support broader economy decarbonisation and shipping and aviation

By 2045:

- Strong domestic response to all transport modes
- Increased emissions awareness leads to permanent behavioural change
- Net zero land transport emissions achieved

By 2025:

- Clear strategy for decarbonising all transport modes with interim targets specified
- Strong government fleet transition response
- Support related zero emission vehicle infrastructure and building policies
- Introduce transition support incentives and policies for businesses and consumers
- Implement government and industry policies to support telecommuting
- Develop Australian manufacturing and recycling industry strategies including incentives to support local and attract international businesses to Australia

By 2050:

- Limited use of offsets for unavoidable transport emissions
- Net zero transport sector emissions

Moving people & goods within cities & regions

Vision for cities and regions

Our cities and regions have the most to gain from decarbonisation and have many of the tools available to tackle transport emissions with existing policy and technology options. For Australia, a clean transport strategy for cities and regions looks like more people out of their private vehicles and utilising active, shared, and public transport, goods being moved using zero emission vehicles, people able to breathe cleaner air and enjoy quieter streets, and households and businesses taking advantage of lower transport costs to spend money on other goods and services.

AVOID policies	Local	State	Federal	Industry
Encourage remote work	✓	✓	✓	✓
Introduce anti-idling initiatives	✓	✓	✓	✓

SHIFT policies	Local	State	Federal	Industry
Support Mobility-as-a-Service (MaaS)	○	✓	○	○
Invest in active transport networks	✓	✓	✓	○
Support electric micro-mobility	✓	✓	✓	○
Support car-sharing	✓	○	○	○
Parking reform	✓	✓	○	○

SHIFT policies (continued)

	Local	State	Federal	Industry
Introduce low emissions zones (LEZs)	✓	✓	✓	
Road pricing reform	✓	✓	✓	
Improve public transport networks	✓	✓	✓	
Improve investment decision making	✓	✓	✓	

IMPROVE policies

Introduce a zero emission vehicle sales mandate		✓	✓	✓
Provide zero emission fleet support	✓	✓	✓	
Introduce a zero emission vehicle incentive scheme			✓	
Introduce a zero emission vehicle company tax benefit			✓	
Reform building policy	✓	✓	✓	✓
Introduce emissions stickers		✓		
Provide consumer support			✓	
Fund urban charging	✓	✓		✓
Enhance grid utilisation and renewable energy uptake		✓	✓	
Develop an EV database		✓	✓	✓
Initiate an EV charging infrastructure register		✓	✓	✓
Support charging infrastructure planning		✓	✓	✓
Transition to WLTP			✓	
Electrify taxis and ride-share fleets	✓	✓	✓	✓
Trial and support zero emission ferries	✓	✓	✓	✓
Consider a future scrappage scheme			✓	

AVOID Policies

NOTE:
A key transport issue facing Australia is urban sprawl and low-density city design. Important structural policies, such as land-use changes, which would reduce trip length and therefore related emissions, are not covered as part of FACTS, but are nonetheless important considerations for Australian governments.

Encourage remote work

Building on the high public support for remote work reported during COVID, governments and industry could strengthen employee access to remote work and flexible working arrangements (PwC, 2021). A recent Australian survey found that of those who retained employment during COVID, 47% stated that their work could be completed at home (Beck & Hensher, 2020).

Enabling ongoing remote work arrangements can lead to a reduction in emissions through reduced trips (Kylili et al., 2020; Shabanpour et al., 2018), while reducing road congestion (Beck & Hensher, 2020; Hopkins & McKay, 2019).

Introduce anti-idling initiatives

Fossil fuel vehicle idling produces avoidable air pollution and emissions, with no transport benefit, and can result in incomplete combustion with elevated emissions. This is particularly relevant in Australia as our fleet has a relatively high proportion of large engine vehicles (Schofield et al., 2017; TER, 2020b). In fact, research suggests that vehicle idling in Australia produces the equivalent amount of emissions as driving more than 1.5 million cars on the road (TER, 2020b).

As an education and health initiative, governments should designate critical anti-idling zones, such as parks, hospitals, and schools (Schofield et al., 2017). Industry and governments should also introduce directives for their fleets to not idle any vehicle unnecessarily (City of San Antonio, 2020).

SHIFT Policies

Set an active and public transport share target

Active transport (walking, cycling, and now micro-mobility) and public transport mode share in Australia remains low compared with international cities, with the 2016 census finding that 19.2% of commuters chose these modes (Cooper & Corcoran, 2018; Engel, 2018).

Australian cities have also been found to perform significantly below European and Chinese cities in terms of access to jobs by active and public transport (Wu et al., 2021).

Particularly with the emergence of new technologies, such as electric micro-mobility, active transport is becoming a more feasible option for commuting, and in turn, an effective mechanism for reducing emissions.

By setting a target of 50% active and public transport commuting share by 2035, Australian governments can coordinate funding for different initiatives to achieve emissions reduction. This aligns with a recent UK transport plan that aims to have 50% of all journeys in towns and cities completed by active transport by 2030 (Crown, 2021a).

50% active and public transport commuting share by 2035

Support Mobility-as-a-Service (MaaS)

MaaS aggregates transport options, including shared vehicles, public transport and last-mile travel options (e.g., shared micro-mobility). MaaS can offer attractive pricing by bundling transport options into a subscription to move away from pay-as-you-go pricing.

To enable the deployment of MaaS programs, state and territory governments should offer wholesale pricing on public transport for Mobility-as-a-Service (MaaS) providers and mandate the sharing of transport service provider data (Sustainability Mobility for All, 2021).

State and territory governments should also cooperate to enable MaaS interoperability such that providers can offer mobility bundles that are valid for use across Australia in different jurisdictions.

Support car-sharing

Car-sharing services offer the opportunity to improve the utilisation of vehicles as private vehicles are typically not in use 95% of the time (Russo et al., 2019).

Local government can support car-share electrification by offering free parking in cities for zero emission shared vehicles until electric vehicles represent 30% of new vehicle sales.

Additionally local government should provide dedicated car-sharing bays with charging infrastructure to provide an easy-entry opportunity for Australians to try, test and use electric vehicles.

Support electric micro-mobility

Australia should encourage and enable the use of electric micro-mobility devices (e-scooters and ebikes) through increased support for shared fleet deployments, and low-interest loans.

Electric micro-mobility is one avenue for enabling a shift from private vehicles. Lime e-scooters found that 30-50% of their Brisbane e-scooter riders reported using e-scooters instead of a car on their most recent trip (Brisbane City Council, 2021). Studies suggest this mode shift can lead to a material reduction in a region's transportation emissions (Cairns et al., 2017; Hollingsworth et al., 2019; McQueen et al., 2020; Şengül & Mostofi, 2021; Sun et al., 2020).

Further, micro-mobility devices were found to increase the cycling population (Dill & Rose, 2012; Hollingsworth et al., 2019), increase physical exercise, (Cairns et al., 2017; Fyhri & Beate Sundfør, 2020), and decrease transport costs (Popovich et al., 2014).

Funding for improved active transport infrastructure is critical for encouraging the use of electric micro-mobility devices.

Parking reform

In the medium-term, local and state governments should cooperate on the introduction of on-street parking caps, with the approval of new parking dependent on existing parking spaces being reallocated to support zero emission transport infrastructure (e.g., charging infrastructure, dedicated active transport corridors), as seen in Zurich and Copenhagen (Taylor, 2018). This aims to both reduce the incentive for private vehicle usage, and improves connectivity for active, shared and/or public transport.

Each parking space has a cost to society via land, construction, congestion, and opportunity costs. However, parking spaces are often provided as public infrastructure, essentially subsidising private travel over other modes (Litman, 2020).

Invest in active transport networks

Australian's will only opt for cleaner transport mode choices(active and public transport)if these options are more attractive or if private vehicles are less attractive.

To improve the experience of active transport in Australian cities, and enable more Australians to feel comfortable and confident in making the switch from private vehicles, Australia should work towards a tripartite government commitment for connecting cycling and walking networks in cities and regions. This effort should have sufficient funding to achieve the 50% active and public transport commuting share target by 2035. Studies have also shown new active transport facilities and corridors can reduce emissions, improve public health and reduce congestion (Ngo et al., 2018; Zahabi et al., 2016).

This aligns with a recent UK transport decarbonisation plan that commits to delivering world class active transport networks and a £2 billion investment to have half of all journeys in towns and cities completed by active transport by 2030 (Crown, 2021a).

Parking reform

A survey of Melbourne found that on-street parking may be vacant 30-70% of the time. Inner-city, onstreet parking, although typically requiring payment, impacts road space allocation and can limit space available for cleaner transport infrastructure (Taylor, 2018). Over supply of parking spaces can stimulate private car ownership and use, with the availability of parking found to be a more significant determinate of car ownership than income and other household characteristics (Russo et al., 2019)

Parking reform has been found to have a significant impact on reducing emissions (Kobus et al., 2013; Russo et al., 2019).

Introduce low emissions zones (LEZs)

International jurisdictions, such as London, have introduced Low Emission Zones (LEZs). This is primarily to reduce local air pollution and improve public health, but also to encourage the uptake of zero emission vehicles (Margaryan, 2021; Peters et al., 2021).

Given Australia's lagging emissions standards, our vehicles are more polluting than comparable international markets (Smit et al., 2021). This is negatively impacting the air we breathe. Local governments should work with state and federal counterparts to directly reduce this air pollution in densely-populated urban areas via the introduction of pay-to-enter emission zones.

Such an approach would have the short-term impact of reducing air pollution, with the progressive tightening of restrictions over time encouraging a transition of the fleet to zero emission vehicles.

We recommend LEZs be introduced nationally by 2025. Initially the emissions penalty for entering LEZs with a vehicle exceeding a set emissions limit could be capped to once per month to provide drivers with the opportunity to make the necessary changes (Brussels LEZ, 2021; Environnement Brussels, 2021).

Ideally, such a scheme would evolve over time so that by 2030 the LEZs include a time-varying rate during the week. This would discourage congestion during peak-hour periods when emissions rates are highest. By 2030, pricing rates should be set such that there is an effective 'ban' on the use of petrol/diesel vehicles in urban areas, in line with the IEA's recommendations for supporting the achievement of net zero by 2050 (IEA, 2021d).

The revenue raised through a LEZ scheme should be directly linked to funding infrastructure to support public, shared, and active transport, and the adoption of zero emission vehicles.

Road pricing reform

While there has long been a need for changes to Australia's complicated road taxation system, our vision for the future of road pricing is one that does not penalise the adoption of zero emission vehicles in the short-term.

We recommend the introduction of a nationally consistent road pricing scheme that:

- Replaces all state-based road pricing schemes.
- Is a replacement for existing road taxes e.g., stamp duty, annual registration fees, luxury car tax, and import tax.
- Applies to all vehicles, regardless of fuel type.
- Includes increasing pricing rates with respect to the vehicle's tailpipe emissions and the value of the vehicle.
- And that is initially voluntary to opt-in to until 2027, after which the scheme will become compulsory for all vehicles nationally.

Ideally, such a scheme would be combined with LEZs in densely-populated areas that include a time-varying penalty to minimise congestion and emissions during peak-hour periods.

The introduction of LEZs would allow for lower road pricing rates, reducing the impact of a road pricing scheme on regional and rural drivers. The majority of revenue would be collected from urban drivers, travelling in high-emitting vehicles, during peak-hour periods i.e., those generating the greatest negative costs for society.

A road pricing scheme should be designed such that regional and rural drivers are no worse off financially, and are not discouraged from adopting zero emission vehicles.

Why pre-mature EV taxes are a bad idea

Road pricing reform is required and should be considered in the context of replacing existing, blunt road taxes, with a dynamic pricing model. This gives us the opportunity to support the uptake of zero emission technologies, while discouraging peak-hour travel – not all travel in general.

Planning and introducing EV taxes prematurely leads to uncertainty in the market regarding the costs of this new technology. Particularly during this early stage of adoption, it is critical that we build consumer confidence to support important interim targets, including at least 55% zero emission light vehicle sales by 2030.

Road pricing schemes that specifically target EVs do not recognise the fact that this technology will deliver net economic benefits (Australian Conservation Foundation, 2021), even after considering the loss of fuel excise revenue.

In contrast, well planned and implemented road pricing reform, combined with positive ZEV policies, can work to support us in achieving net zero emissions by 2050.

We need to pursue a nationally-consistent road pricing scheme that replaces existing road taxes. It should be fair and apply to all fuel types (not just zero emission vehicle technologies) and not disadvantage regional and rural drivers who need to travel longer distances.

Improve public transport networks

As with active transport, Australians are only likely to switch to public transport if the offering is competitive with private vehicles. One key way of improving public transport is to invest in fast, high frequency corridors to create a high-quality public transport network that is more attractive to users (Khan et al., 2021).

High-quality public transport corridors can work in tandem with Mobility-as-a-Service (MaaS), active transport infrastructure, micro-mobility, and shared travel to improve the journey for customers, whilst maintaining coverage.

Currently, in terms of provision of public transport infrastructure globally, Wu et al. (2021) found that Australians' access to jobs by public transport had materially lower accessibility compared to Chinese and European cities.

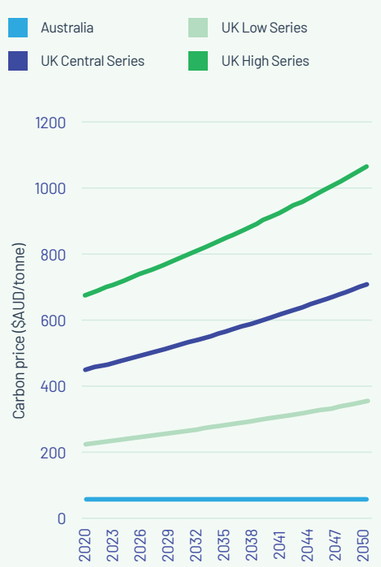
Funding raised through new road pricing and LEZ schemes should partially be used to support the expansion and improvement of public transport services.

Improve investment decision making

Australian transport investment decisions should consider emissions explicitly with a carbon price that adequately reflects our climate commitments, and improves the likelihood of sustainable transport investments. Australia recently updated its carbon price guidance to a static price of just $60/tonne for economic appraisals[3] (ATAP, 2021). However, this price is unlikely to translate into a material shift for decision makers to prioritise decarbonisation and ensure climate impacts are fully accounted for (Crown, 2021c; Veryard, 2021).

Australia should move towards an approach that better aligns with our net-zero commitments, such as that in the UK, which directly links the countries emissions budget (consistent with net-zero) with its appraisal carbon prices. This is approximately $AUD 520 / tonne in 2030 for the central case. Further, the UK's appraisal carbon price increases over time to reflect the diminishing carbon budget (Crown, 2021c). A comparison between the UK policy appraisal approach (with a +/- 50% sensitivity trajectories) against the current Australian approach for transport is illustrated in Figure 14 (ATAP, 2021; Crown, 2021c).

Figure 14.
UK policy appraisal carbon price compared with the ATAP carbon price guidance (ATAP, 2021; Crown, 2021c)



[3] *Note, this carbon price represents the value we as a society place on one tonne of carbon dioxide equivalent, is for appraisal purposes, and is different to carbon pricing mechanisms such as an emissions trading scheme*

IMPROVE Policies

Set a zero emission light duty vehicle target

Almost two-thirds of transport emissions are produced by passenger cars and light commercial vehicles. Although a reduction in emissions was observed during COVID (Commonwealth of Australia, 2020), a rebound and increase in emissions is expected due to:

- **Population growth and commercial activity**
- **Vehicle dependency:** Australia has a vehicle ownership rate of 769 per 1000 inhabitants, compared to the EU at 569 per 1000 inhabitants (ACEA, 2021; Statista, 2021).
- **Ongoing shift to larger and heavier vehicles:** a major factor behind the increasing average fuel consumption rate for cars internationally (Commonwealth of Australia, 2019d; IEA, 2020a), as well as in Australia (TER, 2019).
- **Lack of fuel efficiency standards:** Australia's vehicles have been shown to emit 20%, 45%, and 50% more grams per CO_2 than the U.S., the EU and Japan respectively (TER, 2019), in large part due to the lack of fuel efficiency standards.
- **Low adoption of Low and Zero Emission Vehicles:** Australia's 2021 EV market share (2%) was less than a quarter of the global average (9%), and behind leaders (e.g., Norway: 86%), and similar right-hand drive markets (e.g., UK: 19%).

The solution is ready and available, with strong demand, although Australia is hindered by a lack of policy support

Although this segment is a significant contributor to emissions, light duty vehicles have the advantage of being well suited to decarbonisation via rapidly maturing electric vehicles (EVs). There are already more than 350 EV models available internationally, with projections suggesting over 700 models will be available in the next few years (McKinsey, 2020). On the supply side, 18 of the world's top 20 vehicle manufacturers (which represent around 90% of new car registrations in 2020) are planning to rapidly increase production of EVs prior to 2030 (IEA, 2021a).

However, although there is already significant consumer demand for electric vehicles in Australia (EVC, 2021), supply of electric vehicle models is lagging. There are only around 50 EV models being imported to Australia compared to over 140 models in comparable international markets. Vehicle manufacturers have outlined major challenges to importing models into Australia due to the country's weak policy landscape, especially compared to markets where penalties are imposed for not increasing EV uptake.

Further, most comparable countries have announced future bans on fossil fuel light vehicle sales, the majority starting in the early 2030s. These bans are being announced on the basis of it taking ~15 years for new vehicles to be scrapped, so in order to support net zero by 2050, this requires the last fossil fuel vehicles to be sold in the early-to-mid 2030s.

Australia's current light vehicle targets

In Australia, there is no national light vehicle target for ZEVs. Modelling from the Australian Government predicts sales of just 26% by 2030. However, a number of states have now established targets, or outlined ambitions, in conjunction with incentives, including: SA: 100% sales by 2035, NSW: 51% sales by 2030-2031, VIC: 50% by 2030, and QLD: 200k by 2027, 50% by 2030, 100% by 2036.

It is critical that Australia reaches 100% zero emission light-vehicle sales by 2035 to align with climate targets. Strong interim targets, as described below, will help to ensure early gains support a smooth trajectory to this end.

A fleet of 1 million zero emission light vehicles by 2027

55% zero emission light vehicle sales by 2030 (a fleet of 2-2.5 million vehicles)

100% zero emission light vehicle sales by 2035

100% zero emission light vehicle fleet by 2045

Introduce a zero emission vehicle sales mandate

A ZEV sales mandate is a strong supply side policy which requires automakers to sell a minimum number of ZEVs per year (Sykes & Axsen, 2017). Melton et al. (2017) suggests that a ZEV mandate is one of the most effective policies for achieving ZEV targets and may be necessary to reach emissions targets.

This is one of the most important policy recommendations of FACTS.

This policy is highly likely to improve the availability of ZEV models, with studies showing higher ZEV model availability in jurisdictions with a ZEV mandate (Lutsey et al., 2015; Wolinetz & Axsen, 2017).

Ideally the Australian Government should introduce a national ZEV sales mandate aligned with the new vehicle sales targets outlined in FACTS.

Industry should support these mandates so that Australia can compete for ZEV supply in international markets with similar targets.

In the absence of national leadership, state / territory governments could also introduce ZEV mandates, linked to allowable new registrations by each vehicle brand.

The recommended ZEV mandate is in line with a similar scheme in California. The market mechanism used in California is a tradeable credit scheme, with varying credits based on the ZEV specifications, and a $US 5,000 penalty per credit deficit for manufacturers that miss the mandate target for that year (ICCT, 2019; U.S. DoE, 2021).

As an alternative to a ZEV sales mandate, the Australian Government could introduce fuel efficiency targets, which are designed to achieve a similar outcome of increased ZEV supply, and sales.

Australia could implement fuel efficiency targets from 2023 (modelled off the EU emission performance standards regulation and the New Zealand Clean Car Import Standard) through which manufacturers would pay a penalty for exceeding average fleet emissions targets.

This policy has been shown to directly improve the availability of ZEV models. For example, in the EU it has been reported that their fuel efficiency targets resulted in Volkswagen increasing its EV and hybrid target from 40% up to 60% by 2030 after being fined over $150 million due to being 0.5 g / km over the target for 2020 (Reuters, 2021).

New Zealand has introduced a similar scheme with a new passenger vehicle target of 63.3 grams CO_2 per km by 2027 (New Zealand Government, 2021; NZ Ministry of Transport, 2020a).

If the preference of government and industry is for fuel efficiency targets over a ZEV sales mandate, the progressively falling annual emissions limits should be set to align with the same ZEV sales targets outlined here.

A similar scheme should also be introduced for urban trucks, in line with achieving a target of a 100% zero emission urban truck fleet by 2035.

Figure 15.
Recommended ZEV Sales Mandate Targets subject to modelling

Year	ZEV Sales Mandate
2023	5%
2024	7.5%
2025	10%
2026	15%
2027	25%
2028	35%
2029	45%
2030	55%
2035	100%

Set a zero emission government vehicle target

To lead by example and support the development of a zero emission second-hand vehicle market, all levels of government should commit to introducing electric vehicles into their fleets. This should include targets for 100% of new government vehicles to be 0g CO_2/km by 2023; 100% of the government fleet by 2027; and 100% of service vehicles (e.g. rubbish trucks) by 2030 to align with other international jurisdictions, including:

- United Kingdom: commitment of 100% government car and van fleet to be zero emission by 2027 (Crown, 2021a).
- US: zero-emissions government light-vehicle acquisitions by 2027 and government fleets >20 vehicles must introduce a strategy to deploy infrastructure and maximise zero emission light-, medium- and heavy-duty fleet vehicles (The White House, 2021).
- Belgium: EV procurement quota for public authorities to achieve 100% ZEVs for new sales by 2025 (EAFO, 2021)
- Canada: targets at least 80% of administrative vehicles to be ZEVs by 2030 (Government of Canada, 2021a)
- France: requires 50% of government fleet renewals to be LZEVs (IEA, 2019)

Australian governments should consider bulk orders of zero emission vehicle models not already available in Australia to improve market choice.

Further, the transition to zero emission service vehicles is largely under the control of governments, including: rubbish trucks, fire trucks, ambulances, and police vehicles.

This provides an ideal opportunity for governments to decarbonise part of the vehicle fleet, beyond conventional light duty vehicles.

Some Australian jurisdictions have already introduced electric vehicles into their service fleets, including:

- Electric police vehicles: Police EVs have entered Australian police fleets for trials, adapted from already commercially available electric vehicles (Morley, 2021; Vickovich, 2019).
- Electric rubbish trucks: Electric rubbish trucks are already quietly operating due to local government leadership in Victoria, South Australia, New South Wales, and Western Australia. These vehicles are reported to significantly reduce emissions, complete a full route before recharging, increase available hours of operation due to reduced noise, and decrease operation and maintenance costs (Cleanaway, 2021; Hill, 2020; Schmidt, 2019).
- Electric fire trucks: The ACT recently acquired an electric fire truck, the first in Australia and one of four internationally (Evans, 2021).

100% of new government vehicles to be 0g CO_2/km by 2023 , 100% of government fleet by 2027 and 100% of service vehicles by 2030

Provide zero emission fleet support

To support the transition to electric fleets the federal government should continue to increase Clean Energy Finance Corporation (CEFC) funding to finance fleet and private purchases of LZEVs, with lower interest rates provided to ZEVs.

Federal or state governments could also support companies and departments to make the transition, as done by British Columbia (Canada), via:

- ZEV fleet advisory services to assist with business cases, suitability assessments, finding contractors, electrical modification guidance, and education (i.e., staff presentations)
- Rebates available for telematic tools and ZEV fleet assessments
- Rebates for facility planning assessment
- Rebates for electrical infrastructure upgrades for charging infrastructure
- Training sessions, toolkits, resources, and webinars (Government of British Columbia, 2021b; Province of British Columbia, 2021).

Introduce a ZEV incentive scheme

The federal government should introduce a revenue neutral approach to accelerating the adoption of zero emission vehicles (in addition to state policies) via:

1. A bonus in the form of an upfront financial incentive/tax credit/tax exemption for electric vehicles, coupled with
2. a malus for fossil fuel vehicles via an additional fee weighted towards high-polluting vehicles.

This policy has been found to increase market share by around 5% for every $1,000 offered (Azarafshar & Vermeulen, 2020; Clinton & Steinberg, 2019; Münzel et al., 2019; Narassimhan & Johnson, 2018; Wappelhorst et al., 2020). As such the following incentive amounts are suggested (until 30% of new car sales are reached):

- $7,500 for new vehicles
- $2,000 for used vehicles
- $10,000 for taxis / ride share vehicles.

These amounts are aligned with similar international jurisdictions including:

- **New Zealand:** $NZ 8,625 for new LZEVs and $NZ 3,450 for used LZEVs (McClure, 2021).
- **Canada:** Up to $CAD 5,000 for new or leased LZEVs, in addition to province incentives (Government of Canada, 2021b).
- **France:** Up to €6,000 for a new and €1,000 for a used (0 CO_2 / km) vehicle, and up to €1,000 for a new (<50 CO_2 / km) vehicle (Servicepublic. fr, 2021a).

Financial incentives have been found to require the highest amount of direct government investment of all studied policies (Melton et al., 2020), but need to be sustained over a long period of time to have sufficient impact on uptake (Wolinetz & Axsen, 2017). In a number of jurisdictions, the financial incentive (bonus) has been combined with a malus (penalty) scheme to partially offset costs (Slowik et al., 2019).

The malus would be applied to the sale of new fossil fuel vehicles, weighted towards high-polluting vehicles, and increased over time. Figure 16 includes estimates of the additional cost that would be paid (in AUD) to purchase four of Australia's best-selling vehicles: A Toyota Hilux (~209 g CO_2 / km), Mazda CX-5 2019 (~191g CO_2 / km), Hyundai i30 hatch (~173g CO2 / km), and a Toyota Corolla (~138g CO_2 / km) under malus policies in France, Italy, Singapore and Sweden (Commonwealth of Australia, 2021b; One Motoring, 2021; Service-public.fr, 2021c; The Local, 2021; Transport Styrelsen, 2020).

Figure 16.
Comparison of magnitude of fossil fuel vehicle penalties in different countries. Note these values are conservative as France uses WLTP emissions rates, as opposed to the less-realistic NEDC carbon emissions rates used in Australia.

	Toyota Corolla	Hyundai i30 hatch	Mazda CX5	Toyota Hilux
France	$263	$5900	$15500	$32800
Italy	$0	$2500	$2500	$3100
Singapore	$0	$14500	$24200	$24200
Sweden	$599	$1153	$1441	$2206

The tax revenue raised through the malus penalty would be used to cross subsidise the purchase of low and zero emission vehicles in a highly effective carrot and stick approach. Industry should support this scheme to directly assist manufacturers in achieving the previously outlined ZEV sales mandate.

A similar bonus-malus scheme should also be introduced for urban trucks, in line with achieving a target 100% zero emission urban trucks by 2035.

State and territory governments should also phase-out stamp duty and registration fees for zero emissions vehicles to reduce upfront costs. Ideally this reform would be linked to a fuel-agnostic road pricing scheme – as outlined previously.

Introduce a ZEV company tax benefit

Federal government action is critical to enable companies to transition to ZEVs, and in turn bolster the second-hand ZEV market, via:

- Introduction of a 50% Fringe Benefits Tax (FBT) discount for LEVs (<50 grams CO2 per km), and a 100% discount for ZEVs. This aims to even the playing field, given LEV/ZEV's lower operating costs can result in a lower tax-effectiveness.
- Introduce an FBT exemption for workplace charging. Encouraging daytime charging can help to maximise use of solar electricity.
- Reinstate the $59,136 car depreciation limit for petrol/diesel vehicles with a load carrying capacity of greater than 1 tonne under the instant asset write-off scheme for businesses. This will help fund the removal of this car limit for all ZEVs (regardless of load carrying capacity) until 30% of new car sales are ZEVs.

Set a zero emission bus target

Even though buses contribute only 2% of transport emissions in Australia (Commonwealth of Australia, 2020) there are strong grounds for Australian governments to prioritise the rapid decarbonisation of this mode, including:

- Direct influence: governments have influence over bus contracts and can prioritise zero emission buses.
- Low-hanging fruit: zero emission buses have been deployed globally providing a "quick win" opportunity relative to domestic shipping which contributes comparable emissions.
- Education and awareness: Opting for zero emission buses allows the community to experience the technology first-hand, and better understand the potential benefits of decarbonising transport.
- Growing market: the electric bus market is rapidly expanding internationally (Berlin et al., 2020).
- Strong international policy support: some countries are targeting 100% zero emission urban bus sales by 2025, including Norway, New Zealand, France and Belgium (IEA, 2021c; NZ Ministry of Transport, 2021).
- Cost competitiveness: zero emission buses currently cost more upfront than diesel equivalents and require new infrastructure. However, falling battery prices and increasing economies of scale are reducing upfront costs and, when considering the total cost of ownership, electric buses are already cost-competitive for some applications due to the lower operating costs (BNEF, 2018).

Every state and territory in Australia has committed to net zero targets, however, some are yet to introduce any targets for bus fleet decarbonisation. Current Australian targets include:

- NSW: 100% transit fleet electrified by 2030
- VIC: over half of buses to be zero emission by 2031
- ACT: zero emission public transport system by 2040
- QLD: only zero emission buses purchased for the South East Queensland public transport network from 2025, and for the remainder of the state from 2030.

Australian governments should set ambitious ZEV bus procurement policies, incentivised via longer-term contracts, including targets which align with those in other international jurisdictions, including:

- Norway: 100% ZEV urban bus sales by 2025 (IEA, 2021b)
- Netherlands: 100% ZEV public urban bus sales by 2025, and fleet by 2030 (IEA, 2021b)
- Luxembourg city target to replace all ICE buses with e-buses between 2025 and 2030 (Randall, 2020)
- France: aims for 100% of new public transport buses and coaches to be ZEV by 2025 (IEA, 2020d)
- Belgium: EV procurement quote including public transport vehicles increases to 100% by 2025 (EAFO, 2021)

FACTS recommended target

No new urban diesel buses purchased from 2023 onwards

100% zero emission urban bus fleet by 2030

100% zero emission bus fleet (transit and coaches) by 2040

Introduce emissions stickers

All state and territory governments should introduce a requirement for all vehicles to display a sticker indicating the level of tailpipe emissions in order to support other policies initiatives, e.g., the introduction of low emission zones (stickers assist with identification of high-emitting vehicles), while increasing awareness in the community of the emissions impact of different vehicles.

France requires Crit'Air stickers (air quality certificate) in peak pollution events and within low emission mobility zones. The stickers indicate the pollution category of the vehicle. EVs and hydrogen fuel cell vehicles = Green (Class 0), plug-in hybrid electric vehicles = Violet (Class 1) (service-public.fr, 2021d).

Provide consumer support

We recommend the outdated Green Vehicle Guide website be updated as an immediate priority. The federal government should create a new website / mobile application that provides consumers with factual information on low and zero emission vehicles, live availability of charging infrastructure, accurate well-to-wheel comparisons, and case studies of real Australians who have already adopted a ZEV.

In the UK, this information is bundled into the EV8 mobile application. The app was supported by the UK Space Agency, and helps users to make the switch by providing accurate information, as well as the ability to record their travel patterns and recommend suitable electric vehicles (EV8, 2021).

This move would act to bolster confidence and awareness of clean transport technology options in the community, which remains a barrier to adoption. A 2019 Canadian study found that although many consumers have 'heard of' EVs, their familiarity continues to be low (Long et al., 2019).

Reform building policy

Given the high costs of retrofitting buildings to support EV charging infrastructure, coupled with the long-term nature of building updates, it is recommended that governments work together to future-proof building codes by mandating minimum EV infrastructure provisions (Melliger et al., 2018; Melton et al., 2020). This policy has also been found to increase ZEV adoption via the strong transformation signal sent to the market (Melton et al., 2020). These mandates should include:

- Expanding the draft National Construction Code 2022 to include the requirement that the electrical distribution boards in new and heavily renovated buildings (including Class 1 buildings) are sized to support 100% of car parking spaces (ClimateWorks Australia, 2021).
- Mandate that all government buildings support workplace charging.

What about vehicle emissions standards and fuel efficiency targets?

Australia should catch up to global peers in terms of emission standards and commit to implementing EURO 7 standards in line with the EU by 2025. Australia also remains one of the only OECD countries without fuel efficiency targets, and as a consequence, Australia's vehicles have been shown to emit 20%, 45%, and 50% more grams CO_2 per km than the U.S., the EU and Japan respectively (TER, 2019).

While ideally an average target for light vehicles of <105 g CO_2 per km should be phased in before 2025, in reality, efforts may be better spent agreeing on a ZEV sales mandate scheme that imposes financial consequences on vehicle manufacturers that do not increase ZEV sales in line with the necessary targets of 1 million ZEV sales by 2027, 55% ZEV sales by 2030, and 100% ZEV sales by 2035.

Set a zero emission urban truck target

Rigid trucks, which make up the vast majority of urban trucks, contribute around 9% or 8 Mt / CO_2-e of domestic transport emissions annually (Commonwealth of Australia, 2020). Electric urban trucks are becoming increasingly competitive due to falling upfront costs, and low operating costs, particularly for activities up to 200 km per day. A 2018 study from the North American Council of Freight Efficiency (NACFE) found that medium-duty electric trucks are at or approaching parity with diesel trucks for a number of key parameters, including: typical freight weight, service life, typical daily range, and depot refuelling (NACFE, 2018). The average driving range of electric urban trucks is around ~250 kilometres, with some models available with up to 750 kilometres (CALSTART, 2020). There are limited hydrogen fuel cell variants available at present, but this technology may also play a niche role in the future (IEA, 2021a).

International governments are sending a strong signal to the market through targets. This includes Norway's target of 50% zero emission trucks sales by 2030, and California's target of 100% zero emission trucks by 2045 (Wappelhorst & Rodriguez, 2021). The Netherlands is also leading international policy via the zero emission medium- and heavy-duty vehicle Memorandum of Understanding (ZE-MHDV MoU), which provides a floor target of sales for zero emission medium-duty vehicles of at least 30% by 2030 and 100% by 2040 with increased ambition encouraged over time.
This MoU has been signed by Austria, Canada, Chile, Finland, the Netherlands, New Zealand, Norway, and UK, and was presented at COP26 in November, 2021. (Transport Decarbonisation Alliance, 2021).

FACTS recommended target

100% zero emission urban truck fleet by 2035

Fund urban charging

Governments can encourage the transition to electrification of light vehicles and urban trucks via support for the installation of urban fast-charging infrastructure and destination chargers. The design of this infrastructure should provide charging opportunities for drivers that do not have access to home charging (eg. renters, apartment dwellers, etc.), as well as enable charging of light commercial vehicles and urban trucks. See an example (right) of a charging station in Norway mimicking a conventional petrol station, with a drive-through design.

New infrastructure investment has been linked with increased EV adoption in a number of studies (Melton et al., 2020; Narassimhan & Johnson, 2018; Wang et al., 2019). Further, greenfield urban development should be required to include a mix of charging infrastructure.

Norway's advanced ZEV market share has led to the emergence of charging stations with shorter recharge times and increased flexibility (Hanley, 2021).

Enhance grid utilisation and renewable energy uptake

The timing and shape of the demand arising from widespread direct and indirect electrification of transport is an important issue to consider. If completely unmanaged, this could lead to significant challenges for the electricity grid. Conversely, the direct and indirect electrification of transport provides significant opportunities to provide energy storage and grid balancing services:

- Smart charging enabling electric vehicles to charge during off-peak electricity periods
- Electric vehicles used as mobile batteries, storing and exporting energy to buildings and/or the grid to reduce demand during peak electricity periods, via Vehicle-to-Grid (V2G) infrastructure
- Virtual Power Plants (VPPs) supporting the aggregation of distributed energy resources (including electric vehicles) to extract their full potential
- Production of green hydrogen during peak renewable energy periods

In the short-term, the following policies can help to support and manage this transition:

1. Current grid connection rules impose strict limits on household adoption of battery storage, including vehicle-to-grid chargers, regardless of export limits. To fully capitalise on the energy storage benefits of EVs (and energy storage), grid connection rules should be updated to treat energy storage as distinct and separate from generation assets e.g., rooftop solar.
2. Industry should support the introduction of smart charging programs, providing electricity bill credits to EV owners that voluntarily opt-in to managed charging regimes, and are fairly compensated for supporting grid utilisation and renewable energy uptake.
3. Introduce public charging infrastructure tariffs that are cost-reflective of their impact on the grid, but are tailored to suit the unique nature of their demand profile. Public charging should be viewed as a loss leader for utilities, with revenue recovered through the increased electricity consumption of a growing fleet of EVs charging at home. This reform is critical for supporting additional private investment in public charging infrastructure.

CASE STUDY

Electric vehicles can help to stabilise the grid by soaking up excess renewable energy when charged during the day (highlighting the need for workplace charging). Many new variants also offer vehicle-to-load and vehicle-to-home technology which enable consumers to use their vehicles as a battery-on-wheels.

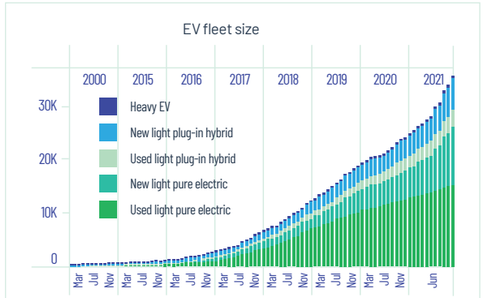
Image: The new Ford F150 lightning pick-up truck offers the ability to fully power a home for 3-days or directly power tools and other devices via 11 onboard powerpoints

Develop an EV database

Data is critical to research and planning, yet in Australia it is difficult to ascertain how many electric vehicles are currently driving around the country.

Australia should adopt an approach similar to that of New Zealand's Ministry of Transport that publishes light and heavy electric vehicle registrations monthly (NZ Ministry of Transport, 2020b).

Figure 17.
A snapshot of New Zealand's publicly available EV fleet data (NZ Ministry of Transport, 2020b)



Initiate an EV charging infrastructure register

A recent AEMO report highlighted that the details of all electric vehicle supply equipment (charging infrastructure) should be captured in an access-controlled register, similar to batteries and rooftop solar (AEMO, 2021). This initiative should be supported to provide a better understanding of current charging infrastructure and be built upon to provide governments with information on where networks may need to be expanded / supported.

This data could also be aggregated and filtered to support a public-facing charging station location website (similar to that of PlugShare) that supports user choice by displaying all publicly accessible chargers, standardisation of information (i.e. charging costs), and user experience via only displaying options which are public, safe and reliable.

Advanced features, such as interoperability between charging networks and real-time availability of charging stations, could be included to further improve user experience and journey planning, in turn bolstering confidence in the technology.

Support charging infrastructure planning

Fund and develop a national charging planning framework to support infrastructure rollout, including mandating fair access to utility information to assist industry in planning for the strategic deployment of charging infrastructure assets.

Transition to WLTP

Under the Australian ADR 79 and ADR 81 standards, the New European Drive Cycle (NEDC) test is still being used. The name is deceptive as the test was developed in the early 1970s and consists of mild accelerations and constant speeds that do not reflect modern driving. The NEDC has been found not be representative of real-world driving. The EU has moved to the more rigorous World Harmonised Light Vehicle Test Procedure (WLTP).

We recommend Australia transition from NEDC to the more rigorous WLTP standard, for more realistic fuel consumption and emissions figures, particularly to provide more accurate information to consumers, including via the federal government's Green Vehicle Guide.

Electrify taxis and ride-share fleets

Given the high utilisation rates of taxis and ride-share fleets, these vehicles produce significant pollution in urban areas, but also provide an opportunity to lead on the transition to EVs.

One of the main perceived barriers to adopting EVs in these fleets is access to charging infrastructure. Governments should work with industry to support the deployment of charging infrastructure in locations that enables the electrification of these fleets.

This policy would complement a bonus-malus scheme designed to provide a higher incentive to these fleets to adopt EVs.

Set a zero emission ferry target

The high diesel use of ferries, particularly in and around urban areas, has seen a number of international jurisdictions consider electric alternatives, including:

- In Sydney, electric harbour ferries have already been deployed (Rabe, 2021).
- New Zealand launched the country's first electric passenger ferry last year, with capacity for 135 passengers (Meridian, 2021).
- British Columbia has procured 6 diesel-electric hybrid passenger (400 persons) and vehicle (47 vehicles) ferries, with the aim to run them on 100% electric power following improvements in charging infrastructure (Little, 2021).
- The largest electric ferry has set sail in Norway servicing a 10 km route and with space for 600 passengers, and 200 cars (or 24 trucks), highlighting the emerging capabilities of electric ferries (Randall, 2021).

Hydrogen ferries may also play a role, with the two first international examples being launched in 2021, one running on gaseous hydrogen in the US (Switch, 2021) and the other in Norway, which is currently running on electric power only, but will run on liquid hydrogen once the fuel becomes available in the near future (LMG Marin, 2021).

100% of government supported ferry fleets to be fossil free by 2035

100% net zero emission ferry fleet by 2050

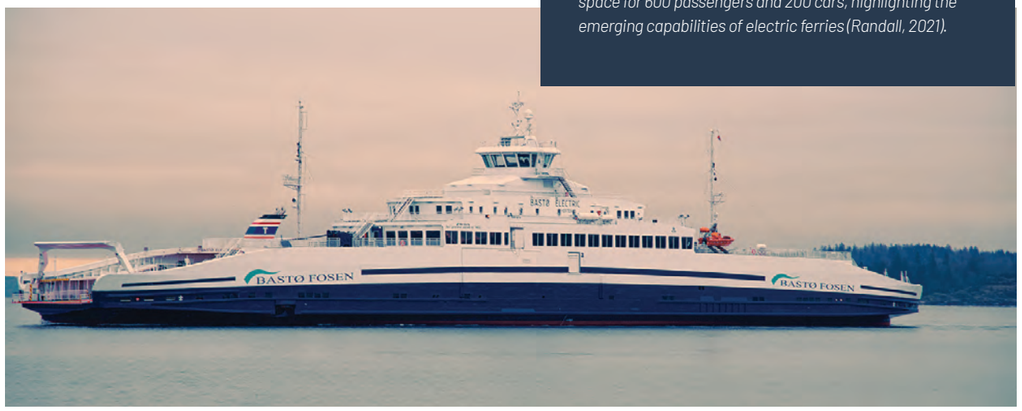
Trial and support zero emission ferries

Australia should plan for the decarbonisation of ferries via electrification or hydrogen due to their high use of diesel, often in urban areas.

There are a number of government-run ferry services in Australia, including Brisbane's CityCats and Sydney's harbour ferries. These ferries would be ideal applications for starting zero emission marine craft trials.

With strategic support from governments, including favourable procurement conditions, and support for trials, Australia can help the boat building sector transition to zero emission marine craft, protecting existing jobs in the industry, while opening new opportunities to export this expertise overseas, particularly across the Asia-Pacific.

An electric ferry in Norway servicing a 10 km route, with space for 600 passengers and 200 cars, highlighting the emerging capabilities of electric ferries (Randall, 2021).



Consider a future scrappage scheme

Once supportive ZEV policies are implemented, the federal government could consider introducing an accelerated vehicle retirement program or scrappage scheme via a credit (to purchase a zero emission vehicle) in return for scrapping older / higher-polluting vehicles (Scrap-it, 2021; service-public. fr, 2021b; Transport for London, 2021).

Such a scheme is suggested for consideration after 2030 (if required) to assist in accelerating the transition of the fleet, with aim of phasing out all petrol and diesel vehicles by 2050. The conditions of the scheme should consider embodied carbon and ensure a life-cycle analysis approach is adopted (TER, 2020a).

Moving people & goods between cities & regions

Vision for transport between our cities and regions

Australia is a big place. To meet our responsibility to deliver climate action will require a strong vision and early efforts to enable critical movement of people and goods between our cities and regions using cleaner technologies. Our regional communities need to be supported to adopt clean transport technologies and access the economic and societal benefits they deliver. The following policies can help to achieve this vision.

AVOID policies	Local	State	Federal	Industry
Reduce avoidable travel	✓	✓	✓	✓

SHIFT policies	Local	State	Federal	Industry
Consider air-travel alternatives	○	○	✓	○

IMPROVE policies	Local	State	Federal	Industry
Introduce a zero emission heavy vehicle sales mandate	○	✓	✓	○
Introduce zero emission heavy vehicle fleet support	✓	✓	✓	○
Introduce zero emission heavy vehicle company tax benefits	○	○	✓	○
Introduce zero emission heavy vehicle design rule exemptions	○	○	✓	○
Introduce zero emission heavy vehicle curfew exemptions	○	✓	○	○
Fund a national charging network	✓	✓	✓	✓
Support electric and hydrogen aviation trials	○	✓	✓	○
Support new technology pilot projects	○	✓	✓	○

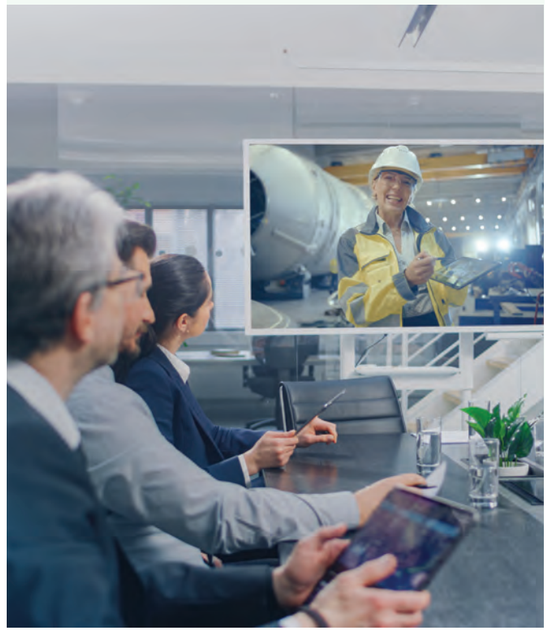
AVOID Policies

Reduce avoidable travel

Both industry and government can help to lead by example in considering their own travel choices and their impact on emissions. Internal workplace policies can help to better measure, track and understand these implications. Workplaces should aim to achieve year-on-year reductions to emissions.

Supportive policies could include:

1. Video conference wherever possible (including to minimise all journeys, not just air travel),
2. Allocate a travel carbon budget to each department (allowing trading between departments) that is reduced year-on-year (Parsons, 2019)., and
3. Use carbon offsets as a last resort to reduce transport emissions.



SHIFT Policies

Consider air-travel alternatives

Transport options for travelling between Australia's capital cities are currently limited, leading to heavy reliance on air travel. In fact, the air route between Sydney and Melbourne has consistently been one of the world's busiest, achieving second place in 2018 (Smith, 2019). Further, both this route, and the Brisbane to Sydney route, are relatively short, taking around 1 hr 25 mins and 1 hr 35mins of flight time respectively (Skyscanner, 2021a).

In France, similar flight routes, such as Paris to Bordeaux (average flight time 1hr 24 mins) will soon be potentially banned, with French MPs recently voting to suspend domestic flights in which a train journey of less than two and a half hours is available (Skyscanner, 2021b; Willsher, 2021). This is possible as France has extensive national coverage of high-speed trains, with speeds of up to 320km/hr (EURail, 2021; Vincent Coste, 2021).

In contrast, the average train speed from Brisbane to Sydney and from Sydney to Melbourne is 73km/hr and 92 km/hr, taking over 10 hours, and making it significantly less attractive than flying (Engineers Australia, 2014).

One study investigated the CO_2 mitigation potential of high-speed rail from Sydney – Melbourne compared to short-haul air travel from a lifecycle perspective. It found that although the inclusion of linehaul infrastructure did increase the CO_2 emissions of high-speed rail, the avoided annual emissions represented a 18% reduction (in the target year of 2056) and an emissions reduction throughout the longitudinal period (Robertson, 2016).

The federal government should consider air travel alternatives, such as improved rail facilities, to decrease air travel emissions into the future. This could be supported through an expanded agenda for the National Faster Rail Agency agenda to focus on increasing rail speeds between Brisbane, Sydney, and Melbourne, using electric trains.

IMPROVE Policies

Set a zero emission heavy truck target

Articulated trucks account for 12% of national domestic transport emissions. This is projected to continue to increase by 2030. With many zero emission options emerging, there is an opportunity to start transitioning this segment of the fleet, starting with shorter-range vehicles, and expanding as options mature. In terms of driving range, the majority of electric models are sitting around 250 kilometres at present, although there are models planned in the near-future at up to 1,200 kilometres. The limited hydrogen fuel cell options in this vehicle class are mostly around 400 kilometres, with predictions this could expand to over 1,000 km in the future (IEA, 2021a).

Industry is moving forward, with manufacturers adding new models as they plan for a zero emissions future:

- **Scania** previously invested in both electric and hydrogen powertrains but has announced a preference for electric variants, noting the lower cost per kilometre and high reliability. By 2025, Scania forecasts ~10% of sales in Europe and by 2030, 50% of total sales will be electric (Scania, 2021).
- **Volvo** announced a complete range of electric trucks for the EU market and has already been attracting record orders (Volvo Trucks, 2021). This is planned to be followed by the inclusion of hydrogen trucks towards the end of the decade, aiming for an entirely fossil free product range by 2040 (Volvo Trucks, 2020).
- **Man** announced their zero emission road map, focusing on electric buses and distribution trucks, while starting testing on hydrogen options for long-haul variants (Man, 2020).
- **Renault** announced the availability of an all-electric option for each market segment by 2023, a target of 35% of sales to be electric by 2030, and a 100% fossil fuel free vehicle range by 2040, noting that electric mobility is the pillar of the strategy, with hydrogen introduced as the technology matures in the future (Hill, 2021b).

100% zero emission heavy truck sales by 2035

100% zero emission heavy truck fleet by 2045

Introduce a heavy ZEV sales mandate

As with light vehicles, the federal government should introduce a heavy ZEV sales mandate as a strong supply side policy. This policy would require automakers to sell a minimum number of ZEVs per year (via a tradable credit scheme, with a penalty per credit deficit) that aligns with manufacturer announcements and includes annual increases in minimum sales - examples shown below. In the absence of national leadership, State / Territory governments could also introduce similar mandates.

Year	ZEV sales target
2025	10%
2030	50%
2035	75%
2040	100%

California's ZEV truck mandate starts with a 5-9% ZEV medium- and heavy-duty sales mandate in 2024, and increases incrementally to 40-75% by 2035, depending on vehicle class.

This policy provides a clear signal to business and industry on the path forward. It is a low-expenditure policy option, encourages increased supply of ZEV vehicles to the market, and may also encourage increased manufacturer expenditure on reducing barriers to adoption to make ZEVs more attractive to purchase (Sykes & Axsen, 2017).

The heavy vehicle industry should work with governments to support the introduction of this sales mandate for heavy vehicles, in combination with financial support to encourage consumer adoption.

Introduce heavy ZEV fleet support

In addition to the zero emission heavy vehicle sales mandate, governments can lead by example, and prioritise contractors that utilise electric heavy vehicles and electric equipment for government contracts, accelerating adoption ahead of required sales targets.

To support other businesses in making this switch, funding should be provided for telematics to help ascertain driving needs and undertake a fleet assessment. An example of this is British Columbia (Canada), which provides this support in two ways:

1. upfront rebates for telematics for businesses (currently for light vehicle fleets) and
2. The use of telematics as a requirement in return for funding support (up to 1/3rd of deployment and infrastructure costs) (Government of British Columbia, 2021a, 2021b; Province of British Columbia, 2021)

Introduce zero emission heavy vehicle company tax benefits

Corresponding to the environmental benefits zero emission trucks offer, the federal government should provide tax benefits for companies that opt for zero emission medium- and heavy-vehicles. We suggest including a 100% immediate tax deduction until 30% of new sales is achieved, to spur adoption of the technology, as is available in Canada (Government of Canada, 2021c).

Introduce heavy ZEV design rule exemptions

Government can help businesses to move towards zero emission trucks by removing current obstacles and amending Australian design rules to support heavy vehicle electrification. This includes increased axle weight limits for electric heavy vehicles, and alignment with international regulation on heavy vehicle dimensions to reduce the barriers for manufacturers to import international models to Australia.

Introduce zero emission heavy vehicle curfew exemptions

Industry calls for greater heavy vehicle curfew flexibility should be met with an exemption from curfews for zero emission heavy vehicles, further incentivising their adoption (ATN, 2020; EVC & ATA, 2021).

As zero emission heavy vehicles contribute significantly less noise pollution compared to their fossil fuel counterparts, this policy can minimise the impact to the urban environment, whilst increasing productivity and financial opportunity, reducing emissions and improving daytime congestion (Allwright et al., 2019; Purnell et al.).

This is a contributing factor to the number of electric rubbish trucks being rolled out internationally, with their ability to minimise the disturbance to residents as they quietly traverse neighbourhood streets.

CASE STUDY

Electric trucks are already in operation and driving around Australia. However, a supportive policy landscape is needed to ensure more models are made available in our market and more Australian businesses have the tools to be able to make the switch.

Some notable examples include:

- IKEA has committed to 100% fleet electrification by 2025 and has already deployed fully electric trucks in its Australian fleet. This includes trucks from Victoria-based SEA Electric, which converts trucks using a proprietary electric drivetrain (Bridie Schmidt, 2019).
- Woolworths, in partnership with Linfox, and as part of their pledge to be net carbon positive by 2050, has introduced a Volvo FL electric refrigerated truck into its Melbourne fleet (Hill, 2021c).
- Australia Post is ramping up its fleet electrification, building on its fleet of 2,100 electric delivery vehicles and 1,400 electric bikes with the introduction of 20 Fuso eCanter electric trucks. The first three have already been delivered (Hill, 2021a).

Fund a national charging network

All levels of government should provide strategic support for charging infrastructure, with the aim to:

- Ensure sufficient private capital will be invested to support a deployment rate congruent with achieving climate targets, particularly for regional drivers where infrastructure costs are the highest.
- Ensure charging experiences are in line with commercial and community expectations:
    - Support for 1 MW+ chargers along high-freight corridors for heavy vehicles
    - Use 350 kW+ chargers in all locations where sufficient electricity network capacity is available
    - Use at least 100kW, but preferably 150 kW chargers at all remaining grid-connected locations
    - Use 50 kW+ chargers in off-grid locations that need to be powered by stand-alone power supply systems

Artificial installation barriers m ust be removed, w ith a process that ensures:

- A timely approval process for fast charging infrastructure.
- Prioritise factors such as night-time safety and disability access.
- Transparent access for industry to information regarding grid capacity to support efficient, and strategic asset deployment.
- Minimise high risk and costs associated with misallocation of infrastructure (Bräunl et al., 2020).

Governments should also work with electricity grid operators to put in place a framework for accelerating the rollout of public charging infrastructure across the country. The framework will identify and support deployment of charging locations to unlock further private investment, while managing risks to the grid.

This framework should prioritise deployment in regional Australia, and support both light and heavy vehicles.

The Australian Government should establish a fund that provides matching support (50%) for a fast (150kW+) and ultra-fast (350kW+) national charging network, and related establishment of micro-grids designed to accommodate both light and heavy ZEVs, at rest stops and at least every 70 km on key transport routes (linked to conditions), increasing to 75% funding in regional and rural communities.

Funding should also be tied to nationally consistent interoperability standards. For example, by mandating the inclusion of credit-card readers or an interoperability protocol, with open access data made available regarding infrastructure location, cost and availability.

Set a net zero emission rail target

This segment currently accounts for 4% of domestic transport emissions (Commonwealth of Australia, 2020). For a net zero transport future, Australia should ensure that the majority of rail applications are electrified where possible. Hydrogen and/or biofuels can potentially play a role in remote regions, or regions with limited access to the electricity grid (Institution of Mechanical Engineers,2019).

Rail can play an important role in reducing private transport demand and road freight with its associated emissions. All forms of public transport offer a low emission alternative to private vehicles (Climate Council, 2017; McIntosh et al., 2014; Replogle & Fulton, 2014).

100% net zero emission rail fleet by 2045

Set a net zero domestic and regional aviation target

Whilst international aviation still remains difficult to decarbonise, Australia should follow other nations in setting ambitious domestic and regional aviation decarbonisation targets.

Our vast country relies heavily on domestic commercial aviation, but also our critical regional aviation connections, from our Fly-In Fly-Out workers, to our Royal Flying Doctor Service. These parts of our transport sector should not be left unsupported in the transition, particularly when zero emission options are rapidly emerging.

These targets should ideally match the ambition of other markets including:

Sweden: Established a roadmap to fossil free domestic flights by 2030 and for all flight originating from Sweden to be fossil free by 2045 (Swedavia,2021).

UK: considering net zero domestic aviation by 2040 (Transport & Environment, 2021a)

US: 20% reduction on aviation emissions by 2030 and 2050 zero fossil fuels (Renshaw et al., 2021).

20% fossil free domestic aviation by 2030
50% fossil free domestic aviation by 2035
Net zero domestic aviation by 2045

Support electric and hydrogen aviation trials

Electric and hydrogen zero emission aviation options are now starting to emerge and could play an important role in achieving net zero emissions, starting with the decarbonisation of domestic passenger and cargo aviation sectors. Short-haul electric and hydrogen aircraft are expected to be available in the next decade, including nine-seat planes capable of short-haul (500-1,000km) flights by 2024 (Jasper, 2021), and small-to-medium 150- seat planes capable of flying up to 500 kilometres by 2030 (Wright, 2021).

This is particularly important for Australia, with the most domestic airline seats per person in the world (Commonwealth of Australia, 2019c), and could also open up the opportunity for new lower-cost regional trips.

Air New Zealand aims to have zero emission planes in its fleet by 2030 (Creedy, 2021). Australia should follow suit, committing to support the trial of zero emission domestic aviation by 2030. Norway has gone one step further, aiming for short-haul flights to be 100% electric by 2040 (Francepresse, 2018).

National support for trials, and research and development, including support for CASA to allow certification of new technology in aviation, would help propel low and zero emission aviation in Australia.

Support new technology pilot projects

Increasing capacity within regulatory agencies to support testing and development of emerging zero emission technologies is important now for ensuring we can decarbonise transport quickly, and within a timeframe congruent with net zero targets.

Australia should adopt a similar policy to that of British Columbia (Canada) which aims to encourage and accelerate the adoption of commercial ZEVs via financial support for vehicles on the condition of data collection and sharing via telematics. This financial support applies to: medium-heavy duty vehicles, ZEV aircraft, ZEV trains, ZEV boats and marine vessels including ferries, and off-road industry vehicles such as ZEV mining vehicles, construction equipment, tractors, etc. (Government of British Columbia, 2021a).

Additional funding should be made available for prioritisation of Australian-made content, and long-term investment in local capability development.

CASE STUDY

Zero emission aircraft of all sizes are expected to enter Australian airspace in the future, examples include (but not limited to):

Delivery drones

Drones, or Unmanned Aerial Vehicles (UAVs) are already in our skies, with services such as WING launching pilot projects in Logan and Canberra (Wing, 2022), and with material international interest including from Amazon, Google, and Deutche Post DHL. These devices, if electric, have been identified as one solution that could help reduce CO2 emissions compared to ground delivery via trucks for small distances, even when considering the additional infrastructure required (Goodchild & Toy, 2018; Stolaroff et al., 2018), along with other potential economic benefits. Stolaroff et al. (2018) finds scenarios could include either direct delivery (close proximity to warehouses), relay of drones supported by urban waypoint stations, or drone delivery between the truck and delivery location (enables trucks to remain on main routes).

eVTOLs (electric vertical take-off and landing)

eVTOLs or passenger drones are expected to accommodate short trips, with extensive research, development and funding ongoing internationally with companies publicly listed and on the path towards certification. In Australia, Skyportz, a Melbourne start-up, has reportedly been working to set up the infrastructure required for air-taxi hubs across Australia (Brisbane Development, 2021).

Zero emission aircraft

Australia's first certified electric aircraft is already in the sky, a two-seater single engine in Western Australia (Kennedy, 2018) however, larger aircraft are in development globally. Short-haul electric aircraft are expected to be deployed in the coming years (ICAO, 2022; Lambert, 2021) and even large commercial aircraft are taking steps forwards, with Airbus recently releasing development plans for large 200+ passenger turbofan commercial aircraft (pictured) (Airbus, 2021).

Moving people & goods in and out of Australia

Vision for international transport

Often international emissions are neglected from domestic discussions as they are currently not included in countries' Nationally Determined Contributions (NDCs) under the Paris Agreement. Rather, the International Civil Aviation Organisation (ICAO), a specialised UN agency, has been tasked with addressing international aviation emissions via CORSIA (Carbon Offsetting and Reduction Scheme for International Aviation) and, for international shipping through the International Maritime Organisation (IMO). Emissions from these transport sectors are still under the influence of Australian governments and industry, and are the most difficult segments to decarbonise, requiring strong, early action to ensure they can contribute meaningfully to emissions reduction targets.

AVOID policies	Local	State	Federal	Industry
Consider virtual international conferences	✓	✓	✓	✓
Support traffic management	○	✓	✓	✓
Introduce carbon pricing	○	○	✓	○
SHIFT policies				
Consider freight choices	✓	✓	✓	✓
IMPROVE policies				
Fund strategic green hydrogen clusters	○	✓	✓	✓
Include international aviation and shipping in targets	○	○	✓	○
Set strategic direction for Sustainable Aviation Fuels	○	✓	✓	✓
Set an airport 2030 decarbonisation target	✓	✓	✓	✓
Introduce a low-carbon ports initiative	✓	✓	✓	✓
International transport R&D	○	○	✓	○
Develop net zero plans for shipping and aviation	○	○	✓	○

AVOID Policies

Consider virtual international conferences

COVID-19 saw the rapid movement of events and conferences online. A recent analysis of a virtual conference, in which a broad range of virtual connection emissions were considered, found that if it was an in person event (where it was expected that 79% of attendees would have flown domestically to attend), the emissions produced would have been 66 times greater (Faber, 2021). Extrapolating to an international conference is likely to further increase the emissions saved.

Duane et al. (2021) found the theoretical environmental impact of an online conference over 2.5 days with 1,374 attendees was 98% lower than the equivalent international in-person conference (4 t CO_2-e, compared to 192 t CO_2-e) when considering a lifecycle emissions.

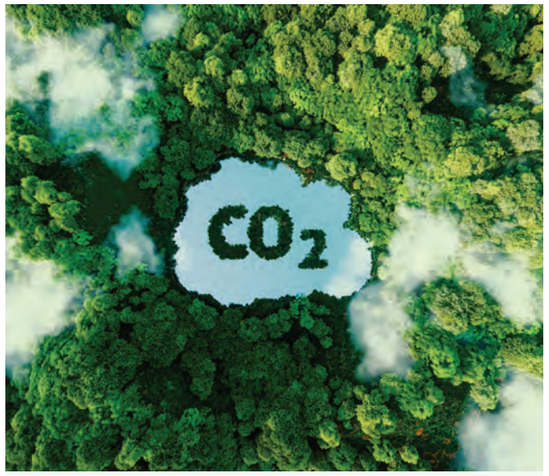
In addition, online conferences can provide time and cost savings, as well as overcome geographical, resource, and disability related barriers (Leochico et al., 2021).

Australian industry and governments should support online international conferences and events, where possible, to avoid related emissions.

Support traffic management

The approach to reducing air and sea transport emissions will need to be multifaceted in order to meet net zero targets. Air and sea traffic management can help support these goals, with studies suggesting these practices can have a material impact on emissions (Eide et al., 2011)

An European Commission proposal to modernise air traffic managements systems and optimise routes is expected to reduce emissions by up to 10% (Shrestha, 2020).



Introduce carbon pricing

Carbon pricing has been highlighted as critical to supporting the use of green hydrogen-derived fuels for international shipping and aviation, with hydrogen (even at a very low cost of $1.50/kg) unlikely to be competitive with heavy marine fuel and jet fuel unless a carbon price is introduced (ETC, 2021b).

Even under the expected European emissions trading scheme's (ETS) carbon price of €80/tonne by 2030, this is likely to be too low for the aviation and shipping sectors, which are expected to require a carbon price closer to $200/tonne to close the gap.

As such, the federal government should commit to at least match the EU scheme of a $125 per tonne carbon price by 2030, to support green hydrogen use in harder-to-abate sectors (ETC, 2021b).

Additionally, all fossil fuel subsidies should be removed to remove market distortions (ETC, 2021b).

As an alternative to carbon pricing, the Federal government should increase aviation fuel taxes to subsidise green ammonia, SAFs, and synthetic fuels.

SHIFT Policies

Consider freight choices

Although air freight is faster than marine freight, marine freight is much more efficient in terms of emissions. The UK Department of Environment, Food and Rural Affairs found that when considering 2 tonnes of freight transported 5,000 km, marine freight emitted 150 kg CO_2-e, compared to 6,605 kg CO_2-e, highlighting the significant difference between the two options (Siegle, 2014).

Australian governments and industry should therefore introduce policies that require justification for air freight, e.g., critical delivery times, and perishable requirements when selecting freight mode.

Further, freight policies should consider distance sourcing from Australia and local regions to reduce freight kilometres.

A carbon price would also be of assistance in shifting air freight to marine freight.

IMPROVE

Fund strategic green hydrogen clusters

Green (renewable) hydrogen infrastructure should be deployed at regional ports, prioritising funding for sites where multiple applications are co-located, including: steel, aluminium, fertiliser and cement.

Critically, this strategic approach to hydrogen investment could support use in marine ships and aviation using hydrogen and/or synthetic fuel derivatives. The use of ammonia in shipping, and synthetic fuel in aviation – both produced from green hydrogen – is expected to be necessary for decarbonising these sectors.

Supporting hydrogen infrastructure at regional port clusters would also enable future overseas exports – if an international market emerges.

Finally, if hydrogen heavy trucks emerge as a viable alternative in the future, these could also be used for land transport servicing these regional ports.

Hydrogen clusters also enable sharing of associated costs and risks of production, transport and storage capacity across multiple end-users (ETC, 2021b).

Include international aviation and shipping in targets

As in other jurisdictions, international aviation and shipping emissions are not included in nationally determined contributions, and therefore not included in emissions reduction targets. They are instead covered by international processes.

For this reason international aviation emissions are difficult to quantify, but they represent a material portion of Australia's total emissions. A 2019 Australian government article noted that "Of Australia's total aviation emissions in 2016, 60% was due to international operations and the remainder due to domestic operations" (Commonwealth of Australia, 2019b). If directly translated to 2020, this would put international emissions at 10.5 Mt CO_2-e, more than doubling the emission reduction task. The reduction of these emissions has been tasked to the International Civil Aviation Organisation (ICAO).

ICAO has set targets of improving fuel efficiency by 2% per year and restraining net carbon emissions at 2020 levels (Australian Government, 2021). However, these targets are likely insufficient to significantly reduce emissions or enable the transformation necessary to decarbonise these transport segments.

ICAO's plan includes technology and operational improvements, adoptions of sustainable aviation fuels (SAFs), and the introduction of market-based measures (i.e., CORSIA Carbon Offsetting and Reduction Scheme for International Aviation) with three phases:

1. Baseline period (2019): eligible airlines to monitor, report and verify emissions from international flights to aid in developing 2019 / 2020 baseline
2. Voluntary offsetting (2021 – 2026): Australia and 80 ICAO Member State (over 76% of international aviation) participate in offset scheme
3. Mandatory offsetting (2027-2035): Mandatory for most member states to participate

During the period 2021-2035, and based on expected participation, the scheme is estimated to offset around 80% of the emissions above 2020 levels (that is, limit emissions growth, not reduce current emissions).

Similarly, Australia's international shipping emissions are currently difficult to ascertain, and delegated to the International Maritime Organisation (IMO) to address. The IMO has set a goal to reduce GHG emissions from shipping by 50% by 2050, which has been noted as achievable only if a large proportion of the fleet is able to commercially adopt zero carbon fuels (Maritime Industry Australia, 2019).

However, the international ambitions of ICAO and the IMO have been criticised. This is most likely a result of needing support from a broad range of global jurisdictions, which leads to the adoption of the lowest common denominator benchmarks. There is a risk that these lower targets will override stronger regional measures. For example, if the CORSIA aviation program targets overrided the EU's robust carbon pricing program, one analysis suggests this could result in 683 million tonnes of additional CO_2 emissions out to 2030 (Transport & Environment, 2019).

To better understand the magnitude of the challenge for these two sectors, international aviation and international shipping emissions should be noted in the report of Australia's national emissions. This would improve transparency and highlight both Australia's total contribution to global transport emissions, as well as the true magnitude of the challenge moving forward. It is therefore recommended that these emissions are included in national targets.

Set strategic direction for Sustainable Aviation Fuels

Connecting Australians and businesses to the rest of the world, whilst aligning with net zero targets, requires early, actionable measures to support decarbonisation and the use of new low-carbon powertrain technologies and aviation fuels.

While electric and hydrogen fuel cell long haul aircraft are being considered (most recently with Airbus unveiling a 2,000+ nautical mile concept hydrogen plane), this technology is more likely to support domestic aviation over the short-to-medium term.

Whilst these zero emission options are being developed, the medium and long-haul aviation fleet can utilise low-carbon, sustainable aviation fuels (SAFs) that can be "dropped-in" to existing aircraft without major modifications to the powertrain or refuelling infrastructure (ICAO, 2021). SAFs typically refer to advanced biofuels (derived from biomass) and synthetic jet fuel, also known as e-kerosene (derived from hydrogen and carbon dioxide).

Compared with advanced biofuels, which can have varying emissions impacts depending on the fuel feedstock, e-kerosene has the advantage of being close to carbon neutral when produced with green hydrogen generated with 100% additional renewable electricity (i.e., not taken from existing resources, therefore reducing emissions reduction potential elsewhere in the economy) and direct air captured carbon dioxide (Transport & Environment, 2021b). In fact, figure 18 below shows that e-kerosene is the critical path to reducing EU aviation emissions (Transport & Environment, 2018).

Australia must move quickly to set a strategic framework for SAFs and provide a clear direction for aviation, to:

- Plan for the considerable investment required to develop and scale up zero emission SAFs, and overcome the first-move barriers required to achieve economies of scale and reduced costs (ETC, 2021b)
- Support the increase in renewable energy generation required (recall the increased energy intensity of green hydrogen - see page 20)
- Overcome the policy time-lag and meet narrowing net zero time frames.

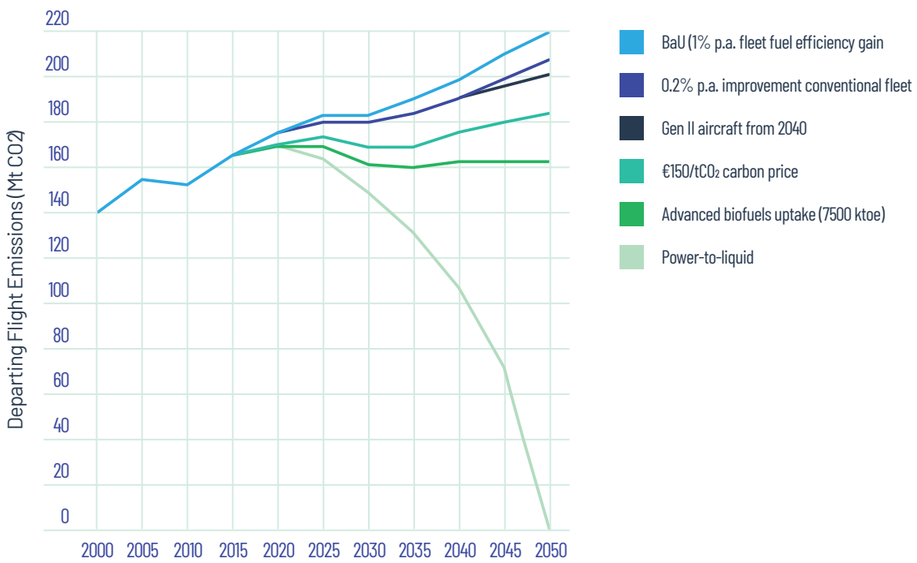
Major Australian airlines have highlighted the need for SAFs as critical to reducing aviation emissions in the medium-term (Qantas, 2021; Virgin Australia, 2021). With Qantas noting that ~95% of emissions are directly attributed to jet fuel, with SAFs potentially reducing these emissions by up to 80% (Qantas, 2021).

Other countries are considering fossil free flight, with:

- **EU:** SAF blending mandates of 91% by 2050
- **USA:** aims to supply 3 billion gallons of SAF by 2030 and sufficient supply to meet 100% aviation fuel demand by 2050

Further, this development could be supported, in part, with a reduction in aviation fossil fuel subsidies, currently provided via a concessional rate of excise levied on aviation gasoline and aviation turbine fuel which was estimated to cost $700,000,000 in 2020-21 (The Australia Institute, 2021).

Figure 18.
Reduction in European departing flight CO_2 emissions in 2050 after demand reduction measures have been applied. (Transport & Environment, 2018)



Sustainable aviation fuel targets
(inc. advanced biofuels and e-kerosene)

2025: **2%**	2030: **6%**
2035: **25%**	2040: **40%**
2045: **49%**	2050: **100%**

20% fossil free international aviation by 2035
50% fossil free international aviation by 2045
100% net zero aviation by 2050

Set a net zero international aviation target

Australia should ensure a holistic transport decarbonisation strategy includes flights originating from Australia in net zero transport targets. This move will ensure accountability and transparency in the industry and align with countries, such as Sweden, which recently announced a target for all flights originating from the country to be fossil free by 2045.

Set a decarbonisation and fuel target for shipping

As with aviation, this segment is expected to be difficult to decarbonise prior to 2050, given the low economic and technological maturity of technologies - particularly for long-haul journeys. This highlights the importance of early investment in R&D to accelerate competitiveness (Gray et al., 2021). This also demonstrates the importance of rapid decarbonisation of easier-to-address segments, such as land transport, to achieve net zero by 2050 at the latest.

> International shipping is fundamental to Australia's ongoing prosperity as it enables our critical exports that underpin our economy... to meet our 2050 targets, we need an unprecedented and coordinated global effort
>
> **Angela Gillham**,
> Deputy CEO of Maritime Industry Australia Ltd
> *(Maritime Industry Australia, 2019)*

The majority of long-haul shipping applications are expected to use low-carbon fuels, ideally able to be dropped in for use in largely unmodified engines, while still reducing emissions (Gray et al., 2021). The direct use of hydrogen may play a limited role in this segment, however, it is challenged by the high costs of retrofitting existing ships, and storing sufficient volumes of hydrogen for long distances. Hydrogen is expected to play a more critical role in producing green ammonia for shipping. However, ammonia is expected to be 55% more expensive than heavy fuel oil, even considering a fall in the cost of green hydrogen to less than $1.50/kg, likely requiring the introduction of a carbon price (ETC, 2021b). Biofuels could also be another important energy carrier for long-haul shipping, but would similarly require the introduction of carbon pricing to reduce the price gap.

Some of the current international policies are detailed below:

- Australia has joined the global shipping sector in announcing a 10-year, $USD 5 billion R&D fund to eliminate CO_2 emissions, with the aim to accelerate the development of commercially viable zero carbon-emission ships by the early 2030s and pay for it using a $US 2 levy per tonne of marine fuel purchased (Maritime Industry Australia, 2019).
- European shipping (EU-regulated including all ships at EU ports or carrying EU trade) initiatives: shipping in the EU emissions trading scheme, deploying sustainable marine fuel, mandating 40% vessel carbon intensity improvements by 2030 compared to 2018, and climate neutrality by 2050 including international shipping (Transport & Environment, 2021).
- Canada has enacted regulations that required all vessels of 400 gross tonnage to have a Ship Energy Efficiency Management Plan and must meet design requirements to increase energy efficiency by 30% by 2025 (IEA, 2017)
- Central Commission for the Navigation of the Rhine (Germany, Belgium, France, Netherlands, Switzerland) adopted a vision for zero emissions from inland navigation vessels by 2050, with an interim target of reducing GHG emissions and pollutants by 35% by 2035, relative to 2015. (Central Commission for the Navigation of the Rhine)
- Netherlands aim to have 150 inland vessels and 1 sea-going vessel with a zero emission powertrain by 2030, a zero emission and climate-neutral inland fleet by 2050, and a 70% reduction from maritime shipping, relative to 2008 with 100% achieved as soon as possible (IEA, 2020).

To support policy development, we recommend the targets detailed below.

50% emissions reduction by 2040
Net zero shipping by 2050

5% low-carbon fuels used in shipping by 2030;
50% by 2040; 100% by 2050

Develop net zero plans for shipping & aviation

By 2025 it is critical that the federal government works collaboratively with industry to develop plans for achieving net zero emissions in shipping and aviation, including consideration of both domestic and international activities, and the offsetting regimes that may be required. Early development of these plans is necessary given the challenging nature of these transport sectors and should also consider the material non-CO_2 impacts such as NOx, NO_2 and water vapour/contrails for aviation.

The UK's Jet Zero Council provides an exemplar of this partnership approach for aviation, bringing together government and industry (e.g., airports, airlines, manufacturers, and universities) with strong, clear goals spanning a multi-faceted approach with specific delivery groups to deliver the overarching goal of zero emission transatlantic flights (Crown, 2021b).

Where should offsets come from?

Although Australia should commit to implementing measures now to ensure transport decarbonisation measures are reached before 2050, there may remain the need to offset emissions.

Australia should ensure all offsets associated with net zero transport are local to Australia to ensure direct control, as well as capture the additional benefits, such as: economic support for landholders, farmers and first-nations peoples, increased habitat for Australian wildlife, and healthier and more resilient landscapes (Queensland Government, 2021)

Set an airport 2030 decarbonisation target

A holistic approach to decarbonising transport should be advocated, including net zero targets for international (and ideally domestic and regional) airports by 2030, in line with our international peers. This policy would build on the existing Airport Carbon Accreditation Scheme.

In fact, the main airport operator in Sweden, Swedavia, already achieved net zero across its 10 airports in 2021 (CAPA, 2021).

In Australia, Sydney Airport has set a 2030 net zero target. This will be achieved, in part, via reducing electricity use, switching to renewable energy, and transitioning to low and zero emission technologies.

Introduce a low-carbon ports initiative

Australia should support low and zero emission marine vessels by measures such as: the introduction of differentiated port pricing that rewards low and zero emission marine vessels, support for the refuelling of these vessels, and renewable energy for direct berth powering.

This could extend to a mandate on the share of green shipping in total traffic applied at port levels as suggested by the ETC (2021b).

In the long-term, a penalty could be imposed on high emitting ships entering Australian ports, which could be used to cross-subsidise port costs for low-emission vessels.

Support international transport R&D

Australia should invest in R&D to support the development of global solutions to low and zero emission ships and aircraft. This could include the provision of Australian-made fuels, components and resources to support international manufacturing of these vehicles.

Upstream and downstream policies

Vision for a holistic transport strategy

Our clean transport future supports a holistic view of the transition, enabling the introduction of cleaner technologies both upstream (e.g., critical minerals and fuel production) and downstream (e.g., recycling and skills support).

Upstream policies	Local	State	Federal	Industry
Enhance Australia's critical minerals strategies	○	✓	✓	○
Incentivise local component production and vehicle manufacturing	○	✓	✓	○

Downstream policies	Local	State	Federal	Industry
Incentivise local component recycling	○	✓	✓	○
Invest in local skills development	○	✓	✓	✓
Retrofit support	○	✓	✓	✓

Becoming a global supplier of critical minerals

Australia is well placed to support the global transition to clean energy technologies, including ZEVs, given it is a reliable and responsible supplier of many of the minerals critical to the manufacturing of these technologies. Australia is the world's largest producer of lithium and zirconium concentrate, and the second largest producer of rare earth elements (Commonwealth of Australia, 2019e).

The Australian Government's Critical Minerals Strategy aims to expand this potential, establishing a Critical Minerals Facilitation Office with goals including: attracting investment, partnering internationally on global supply chains, facilitating research, and providing financial support to prospective critical mineral projects in Australia. In March 2021, the strategy was expanded via the launch of the Resources Technology and Critical Minerals Processing road map, allocating funds to enhance the country's critical mineral processing capabilities, and maximise the value of the nation's critical minerals. As shown in Figure 19, there is significant global market potential for many critical minerals available in Australia.

Figure 19.
Table of critical minerals in Australia – select critical minerals. (Commonwealth of Australia, 2019a)

Critical mineral with high Australian geologica potential	Australia's economic demonstrated resource	Australia's current yearly production	Global production	Estimated global market value ($US)
Cobalt	1221 kt	5 kt	100 kt	$541.8 M
Lithium	2803 kt	14.4 kt	42 kt	$1430.6 M
Rare earth elements (REEs)	3270 kt	14 kt	130 kt	$415.4 M

Even more critical for Australia, given the anticipated decline in coal production over the coming decades, is the need to invest in new minerals to support local jobs and maintain our economic prosperity. The IEA expect that although global revenue from coal is currently ten times larger than critical minerals, this standing will reverse well before 2040 under their Sustainable Development Scenario (SDS) i.e., net zero by 2070. This reversal would need to occur even faster to achieve net zero emissions by 2050, and will require increased policy ambition and support, beyond current efforts.

Local manufacturing of supply chain components and vehicles

There is discussion around Australia on how local manufacturing of zero emission vehicles can be supported. While a worthy endeavour, governments need to take a holistic view of the entire value chain to enable this ultimate goal.

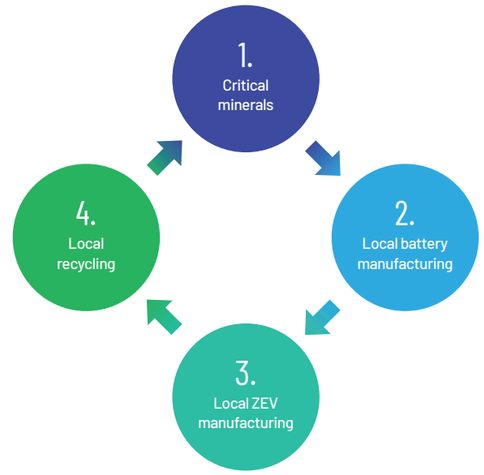
In the case of all zero emission vehicles, batteries are a major powertrain component, and a significant cost.

Some local battery manufacturing facilities are under investigation, including the Townsville Magnis Battery Factory (Mazengarb, 2020). However, given there is currently no local battery manufacturing, local ZEV manufacturers (or assemblers) are reliant on importing batteries from overseas, generally in small quantities. This leads to high costs, making it difficult to compete with imported models.

To support local ZEV manufacturing, a local battery manufacturing industry needs to be supported, which in turn requires a ramp up in the supply of local battery minerals, and mineral refining.

Governments need to support all segments of the value chain simultaneously and have a particular focus on mineral supply and battery manufacturing if they are serious about supporting local ZEV manufacturing in the medium-term. These local capabilities can also support the development of a local component recycling industry.

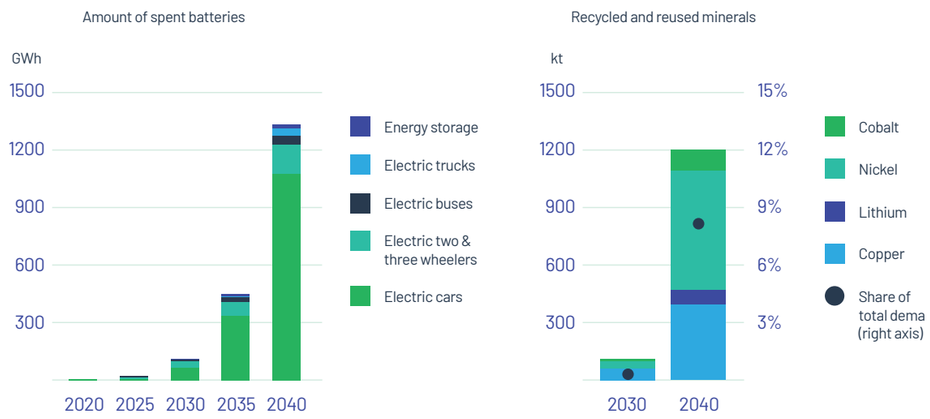
Figure 20.
Full value chain for enabling local manufacturing of ZEVs



Component recycling and second-life applications for a holistic approach

Although the recycling of ZEV components is not yet a major industry, it is forecast that demand will increase significantly over the coming decades. This will include the recycling and reuse of batteries, electric motors and potentially also hydrogen fuel cells, and electrolysers for hydrogen production. The IEA expects that by 2040 recycled and recovered cobalt, nickel, lithium, and copper from spent batteries could reduce primary demand requirements by around 10% - see Figure 21.

Figure 21.
Contribution of recycled battery materials to primary demand. (IEA, 2021e)



If Australia were to accelerate local energy transition mineral extraction and processing, local battery manufacturing, and ZEV manufacturing and adoption, a further economic development opportunity would arise to significantly expand our local component recycling industry.

Supporting end-of-life recycling will also help to bridge the gap between demand and supply for critical minerals over the coming decades and is likely to be critical to achieving net zero emissions globally by 2050.

A number of nations are already moving to establish battery recycling facilities overseas. Australian governments should take a broader view on how the nation can first reuse spent batteries, electric motors, hydrogen fuel cells, and electrolysers. The components could then eventually be recycled back into the components to feed back into the primary mineral supply chain, and in turn, the manufacturing sector.

Potential for reusing components as a first step in the recovery cycle should not be underestimated. Batteries are expected to continue to remain suitable for use in grid applications for 10 to 15 years following useful life in an EV. Electric motors are expected to last for more than 1 million kilometres – well and truly above the average life of light vehicles. This opens up the possibility for reuse in other vehicles or applications. Further investigation is required to understand whether any second-life applications exist for hydrogen fuel cells and electrolysers.

Upstream & Downstream Policies

Enhance Australia's critical minerals strategy

The Federal and State/Territory governments should build on the current national critical minerals strategy to providing specific funding to:

- Support accelerated extraction, processing and refining of resources critical to the LZEV supply chain, including: Lithium, Nickel. Cobalt, Iron Ore, Graphite, Alumina, Rare Earth Metals, Platinum, etc.
- Support for local manufacturing and recycling of batteries for use in LZEVs, including supporting local manufacturing, and the attraction of global manufacturers to the Australian market
- Provide tax relief for companies that deploy ZEVs in local mining operations.

Incentivise local component recycling

Allocate funds to support the expansion of a local component recycling industry for batteries and / or fuel cells, including company tax and payroll tax relief.

Invest in local skills development

Mandate that all TAFE mechanic courses in Australia provide training in the service and maintenance of zero emission vehicles and fund the development of courses to upskill existing existing mechanics in the service and maintenance of zero emission vehicles.

Incentivise local component production and vehicle manufacturing

Allocate funds to support companies that invest in local zero emission vehicle and component manufacturing in Australia, including company tax and payroll tax relief.

Retrofit support

To reduce stranded assets and re-use the existing transport vehicle and vessel fleets Australia has already invested in, retrofitting support should be considered and supported – where cost-effective and appropriate - primarily for shipping and aviation.

What can you do?

Australia is in the fortunate position of having many options available to us on our journey to net zero transport. But these opportunities will not last forever. We must seize the moment, and capitalise on the new jobs that this transition can deliver, while reducing our transport costs, our energy costs, improving our national security, and importantly, cleaning up the air that we all breathe.

This document is a call to action for Australian governments and industry to consider and incorporate our policy recommendations, in support of achieving the decarbonised transport targets outlined in this strategy.

This is also a call to all Australians to contact their local, state/territory and federal representatives, share the Transport FACTS with them, and outline what you think they should do to support the decarbonisation of transport in Australia.

If you would like to find out more about **FACTS** please go to: **TRANSPORTFACTS.ORG**

We want to hear what a clean transport future looks like to you!

Go to **TRANSPORTFACTS.ORG** and let us know about your vision for a net zero emission transport system in Australia.

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