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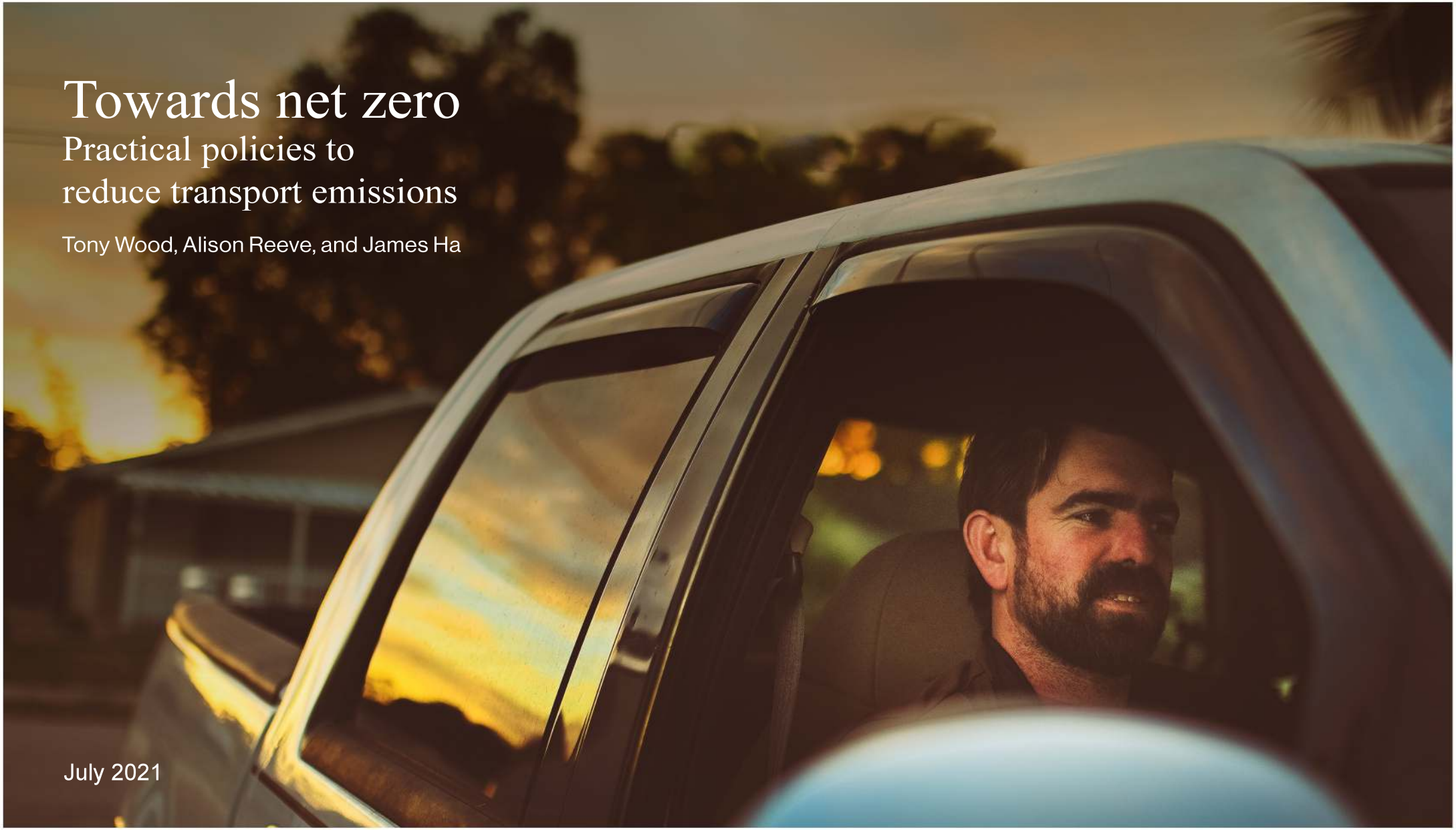

Towards net zero

Practical policies to reduce transport emissions

Tony Wood, Alison Reeve, and James Ha

July 2021

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Overview

Governments around the world are moving to ‘net zero’, to limit the impacts of climate change. All Australian state and territory governments have the goal of reaching net-zero carbon emissions by 2050 at the latest, and the Prime Minister says the national goal is net zero, preferably by 2050.

Yet Australia is not on track to hit this target. The best way to reduce emissions in every sector in an economically efficient way would be to introduce a single, economy-wide emissions price coupled with support for technology development and removing non-price barriers. But the political reality is that carbon pricing is out of reach, at least for now. So Australia should pursue sector-specific policies.

Australian governments can and should act now to create momentum towards the net-zero goal. This report, the first in a series on net zero, recommends policies for the transport sector, which was responsible for 18 per cent of Australia’s emissions in 2020.

Annual emissions from transport grew from 82 million tonnes in 2005 to 101 million tonnes in 2019. The reasons include population growth, larger vehicles, increased freight movements, and more flights. Emissions dropped sharply, by 7 million tonnes, in 2020 due to the COVID-19 pandemic, but the Federal Government projects they will rebound and reach 100 million tonnes by 2030.

The best way to cut transport emissions is to switch to zero-emissions vehicles, mainly battery electric vehicles, in the light vehicle fleet. The range, performance, upfront price, and total ownership costs of zero-emissions vehicles are rapidly improving. But relying on technology and market forces alone won’t be enough to get on track for net zero by 2050.

The vehicle fleet takes more than 20 years to replace; any new petrol and diesel cars sold in the 2030s could still be in use after 2050. Australia needs a national fleet emissions standard for new passenger and light commercial vehicles, and the standard should tighten to zero emissions by 2035. This would signal an end date for the sale of new petrol and diesel light vehicles, consistent with other major economies and with International Energy Agency advice. And it would encourage car manufacturers to supply low- and zero-emissions vehicles that meet Australian consumers’ range and performance demands.

Governments should encourage a thriving market for zero-emissions vehicles by exempting them from inefficient taxes such as import duties, luxury car tax, and motor vehicle stamp duty. They should ensure drivers across the country have somewhere to charge electric models.

Cutting emissions in the light vehicle fleet would ease the pressure to find emissions reductions in other modes of transport, such as aviation and long-distance trucking, where affordable alternatives to fossil fuels are harder to identify. In these sectors, governments should make small bets on all the alternatives, and plan scenarios for each should it become the clear winner. Increasing the truck width limit to match the US standard would mean zero-emissions models designed for overseas markets could be more easily adapted for Australia. A renewable hydrocarbon fuel target would also be a smart bet, especially for the aviation industry.

Action today is crucial to avoid locking in emissions for decades to come, and to ensure the transport sector contributes to Australia reaching net zero by 2050. Governments have set the goal; this report identifies the practical, no-regrets policies they can adopt to steer Australia in the right direction.

Recommendations

1. Ensure emissions from light vehicles are systematically reduced, and that Australians have the widest choice of low-emissions and zero-emissions vehicles

- Set a mandatory fleet emissions standard, applied to the sale of all new light vehicles, tightening to zero emissions by 2035 to set an end date for sales of new petrol and diesel light vehicles.

2. Scrap inefficient taxes and regulations that slow Australians' take-up of zero-emissions vehicles

- Scrap import duties and stamp duty on zero-emissions vehicles, and waive luxury car tax on such vehicles for the rest of the decade.
- Increase the truck width limit in Australia from 2.5m to 2.6m to ensure any zero-emissions heavy vehicles made for the EU or US can be used in Australia without expensive modifications.

3. Ensure buildings and the electricity grid are electric vehicle-ready

- Update the National Construction Code to require that all new buildings with off-street parking include electrical cabling to allow for an appropriate number of future vehicle chargers.
- Require all leased dwellings with off-street parking to have an electrical outlet near each car space by 2030.
- Plan now to ensure convenient, local vehicle charging is available by 2030 for all residents of homes without off-street parking.
- Plan the electricity tariff reforms necessary for smart management of vehicle charging in future.

4. Test all options for reducing heavy vehicle and aviation emissions

- Support targeted trials of zero-emissions trucks, particularly hydrogen trucks, to assess their performance under Australian conditions and practices.
- Develop national standards and certification for renewable hydrocarbons (low-emissions fuels, generally made from biomass or waste, that can be blended up to 100 per cent with no engine modification), based on their emissions intensity, building on work already being done on hydrogen.
- Establish a renewable fuel standard for diesel, aviation fuel, and shipping fuel, that requires fuel wholesalers and retailers to buy certificates or to blend small amounts (e.g. 1 per cent) of renewable hydrocarbons into fuels sold by 2025, with the target rising in following years.

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1 The time is right for practical climate action

Australia has suffered more than a decade of policy uncertainty on climate change. Despite increasing international ambition and increasingly urgent calls for action, political differences between and within major parties have held back progress.

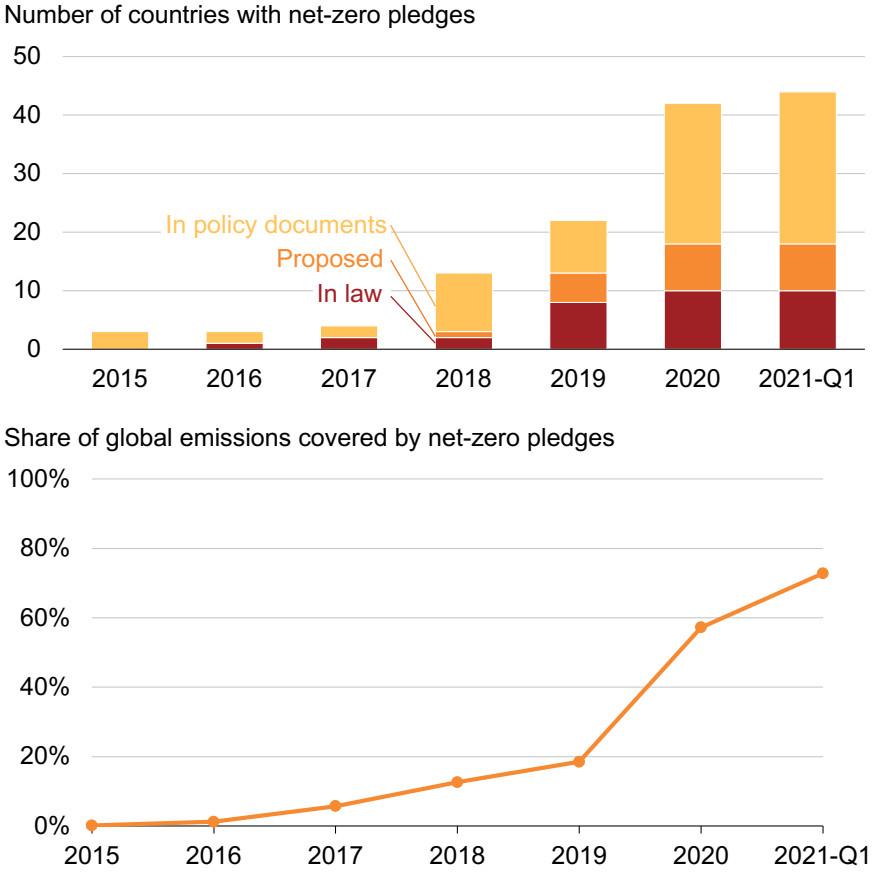
Nevertheless, converging international and domestic political pressures have created a window of opportunity for progress on climate change policy. Political reality means the best policy – a single, economy-wide emissions price – is out of reach for the foreseeable future. Therefore, the most pragmatic approach is a combination of sector-based, technology-driven policies that will create momentum towards greater ambition at a later date.

In coming months, Grattan Institute will publish a series of five reports identifying the options for practical emissions reductions in key sectors. This first report focuses on transport emissions.

1.1 International and domestic pressure to cut emissions is mounting

The international community has shifted towards greater climate ambition in the past 12 months (Figure 1.1). The US has rejoined the Paris Agreement and committed to reduce emissions to net zero by 2050. The EU, having already made that commitment, is considering tariffs on imports from nations with inadequate climate policies.[1] Many of Australia's largest trading partners have now set net-zero targets, including China, Japan, and South Korea. All Australian states and territories have targets to reach net zero by 2050 or earlier,[2] and the

Figure 1.1: The international community is now serious about achieving net-zero emissions



Source: IEA (2021a, p. 33).

1. K. Taylor (2021).
2. Henry and Chandrashekeran (2021).

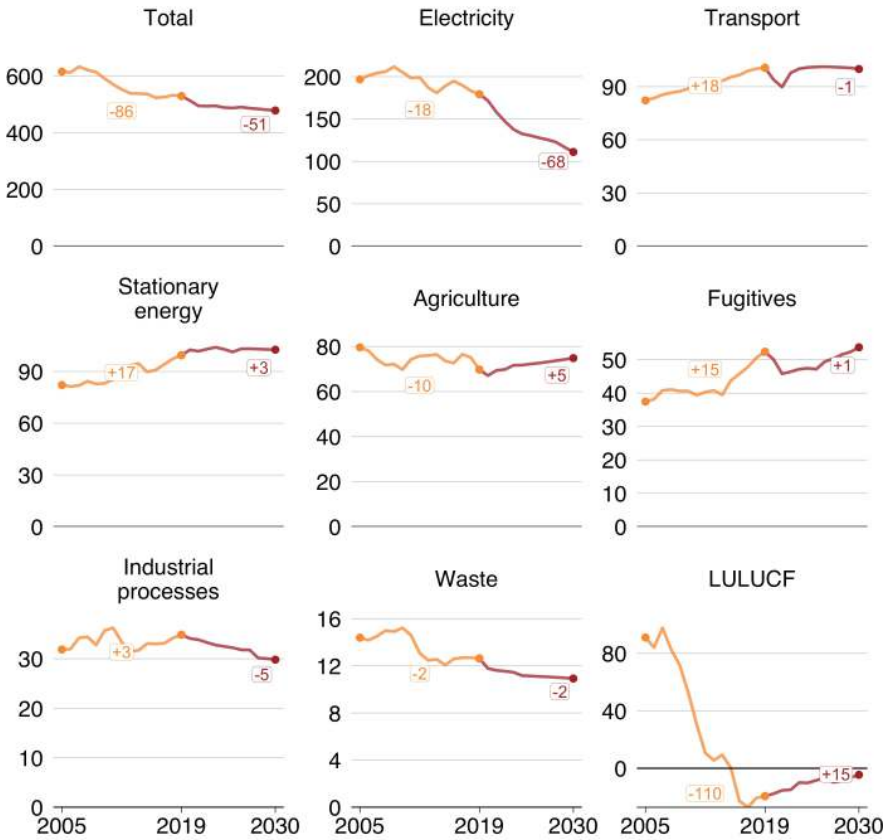
Prime Minister also says he wants to achieve that goal as soon as possible, preferably by 2050.[3]

Global action on climate change is overwhelmingly in Australia's national interest.[4] The Federal Government has ratified the Paris Agreement, which means Australia is committed to helping limit global warming to well below 2℃, and ideally to below 1.5℃.[5] To achieve this, there is a limit to how much carbon pollution the world can emit – a 'carbon budget'. Staying within that budget is the real objective.

Achieving net-zero emissions by about 2050 is necessary to have a decent chance of limiting global warming to 1.5℃. But it matters how the world – and Australia – gets there.[6] Continuing to release emissions at the current rate until 2049 – or even until 2040 – would blow the budget, while requiring an impossibly fast transformation to net zero by 2050. On the other hand, cutting emissions faster today will save more of the budget for the future, buying us time to ensure a smoother transition for our economy and communities. The emissions sources that are cheaper and easier to decarbonise should be targeted first; the harder-to-decarbonise sources should come later. Building momentum, coupled with R&D in low-emissions technologies, will make easier in the future what seems hard now.

Over the next decade, Australia's electricity emissions are projected to fall substantially, but the next four largest emissions sources in Australia will either grow or plateau at best (Figure 1.2). This comes after sustained growth in emissions in several sectors since 2005. There is a market failure here: limiting global warming to 1.5℃ is in Australia's interest, but current incentives are too weak for companies and individuals to curb their emissions in line with this target. If

Figure 1.2: Apart from electricity, there's very little emissions reduction expected in Australia over the next decade
Emissions per year (millions of tonnes)



Notes: 'LULUCF' = land use, land use change, and forestry. 'Stationary energy' is the use of fossil fuels for non-electricity, non-transport purposes, such as burning gas for heat in industry. 'Fugitives' are non-energy emissions released alongside the extraction of fossil fuels, such as carbon dioxide trapped in gas reservoirs. Emissions are 'carbon-dioxide equivalents', estimated using using the 100-year global warming potentials published alongside IPCC (2007).

Source: Grattan analysis of DISER (2020a).

3. Morrison (2021).
4. Wood et al (2021, Chapter 1).
5. UNFCCC (2015).
6. Hoegh-Guldberg et al (2018).

government policy does not bend these curves downwards this decade, Australia faces a faster, harder transition to net zero by 2050 – it will need to reduce its annual emissions by 24 million tonnes each year for 20 years (Figure 1.3).

1.2 The best policy is off the table, so Australia needs a practical 'second-best' approach

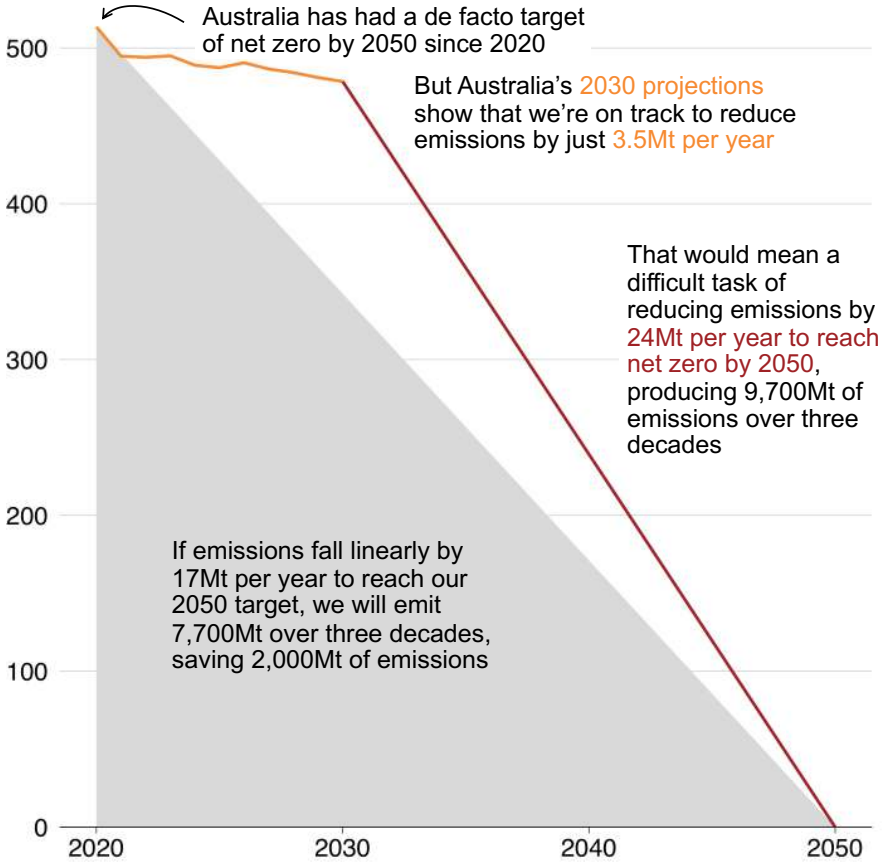
The most practical approach to reducing emissions for now is a combination of sector-specific policies. While an economy-wide carbon price would be more efficient, the political reality is that Australia is unlikely to re-establish such a price any time soon (Box 1 on page 10).

This transport report is the first of a series on sector-based approaches. The other four reports will cover industrial emissions; agriculture and land use; the role of offsets; and the electricity sector. Each will analyse emissions sources; pathways and technologies for reductions; technological and economic challenges; and existing government initiatives. Each report will provide sector-specific recommendations.

The over-arching theme of these reports is that Australia needs real progress in each sector to meet governments' preferences for achieving net-zero emissions economy-wide by 2050. Each sector has its own challenges and opportunities, but within each are categories of potential actions:

- Those where the costs are understood and either competitive or rapidly becoming so, the emissions abatement impact is clear, and policy is straightforward;
- Those where the costs are understood but expensive, and where there are barriers to implementation beyond cost; and
- Those which seem very difficult to implement and whose costs are unknown or difficult to quantify.

Figure 1.3: If there's insufficient progress by 2030, a highly disruptive economic restructuring will be needed in the 2030s and 2040s
Emissions per year (millions of tonnes)



Notes: Emissions are 'carbon-dioxide equivalents'. The two trajectories depicted do not have an equal effect on the climate, despite both reaching net zero by 2050 – it is the total amount of emissions in the atmosphere, not the annual contribution, that drives climate change.

Source: Grattan analysis of DISER (2020a).

In the absence of an economy-wide emissions price, it is policy makers rather than the market who must decide where to reduce emissions. In this series of reports, we are aiming for the lowest-cost, no-regrets emissions reductions in each sector first, even though this approach will be less efficient than an economy-wide market-based policy.

Generally, we will start from existing policies and orient them towards a common goal, rather than propose wholesale changes. We will prefer policies that are technology-neutral with respect to achieving the net-zero goal, except in the cases where the 'winner' is already obvious. Crucially, we see a role for technology *and* incentives *and* regulation, because a combination of the three will ensure appropriate risk-sharing between the public and private sectors.

It should be possible for major parties to adopt our recommendations – whether for presentation at the international climate conference in Glasgow in November 2021, or for domestic policy platforms – but retain differentiated views on detailed policy design and the best mix.

Much public conversation on setting and achieving a net-zero goal for Australia focuses on activities and changes that are expensive and difficult. This neglects the actions that we can take now, whose successful implementation will build confidence and momentum. This report series will focus on policies that can be implemented now, with some suggestions for the longer term where relevant. None of our recommendations by themselves can deliver the full net-zero outcome, but they will all help orientate the economy in the right direction.

Box 1: Why this report focuses on one sector rather than an economy-wide policy

Australia has 29 years to transform its economy if it is to reach net zero by 2050. As Figure 1.3 on page 8 shows, the slower we progress this decade, the steeper and more disruptive the pathway to net-zero emissions becomes.

It is well-accepted that the most economically efficient way to achieve large emissions reductions across the economy is through a carbon price. Done well, economy-wide carbon pricing ensures that the sectors most able to make cheaper emissions reductions do so; the result is emissions reduction at lowest cost.[a] Carbon pricing is supported by the business community and economists.[b] It should form the bedrock of an effective suite of policies to achieve net zero.[c]

But carbon pricing has a long and difficult history in Australia: a price was taken to election by both parties in 2007, introduced in 2012 (though it was far from perfect, with many compromises to appease political and vested interests), and repealed in 2014 after being successfully labelled as a 'tax' by then-Opposition Leader Tony Abbott. A carbon price is now not seen as politically feasible by either major party, and the current Federal Government has ruled out any new policy that resembles a 'tax'.[d]

If Australia is to meet its climate objectives, policy is needed to reduce emissions now, sector by sector. This is a more costly way to reduce emissions than a carbon price because governments, not the market, have to decide where to reduce emissions. Nonetheless, governments should be able to meet their climate targets reasonably efficiently if they target the lowest-cost abatement opportunities in each sector.

Sector-based policies have delivered emissions reductions and survived political battles. For example, the Renewable Energy Target (introduced by the Howard Government in 2001 and reviewed and amended by successive governments since) has been so successful in increasing the renewable share of the electricity sector at reasonable cost[e] that many argue it is no longer necessary.

Starting with sector-based policies does not rule out a future economy-wide policy. In the meantime, it is better to start bending the emissions curve downwards with sectoral policies. Making sectoral progress would build momentum and confidence that the task of reaching net zero is possible. Once we are moving, it will become easier to move faster.

a. Wood et al (2016, p. 10).
b. BCA (2020); and Wood (2020).
c. A carbon price would need to be complemented by support for low-emissions technologies development and regulation in sectors with barriers to adoption. For example, there is a split-incentive problem in buildings where emissions from gas heating would be paid by tenants, but only the building owners can authorise upgrades to lower-emissions electric heat pumps. In this case, minimum building efficiency standards would probably be a more effective policy.
d. Wood (2021).
e. CCA (2014a).

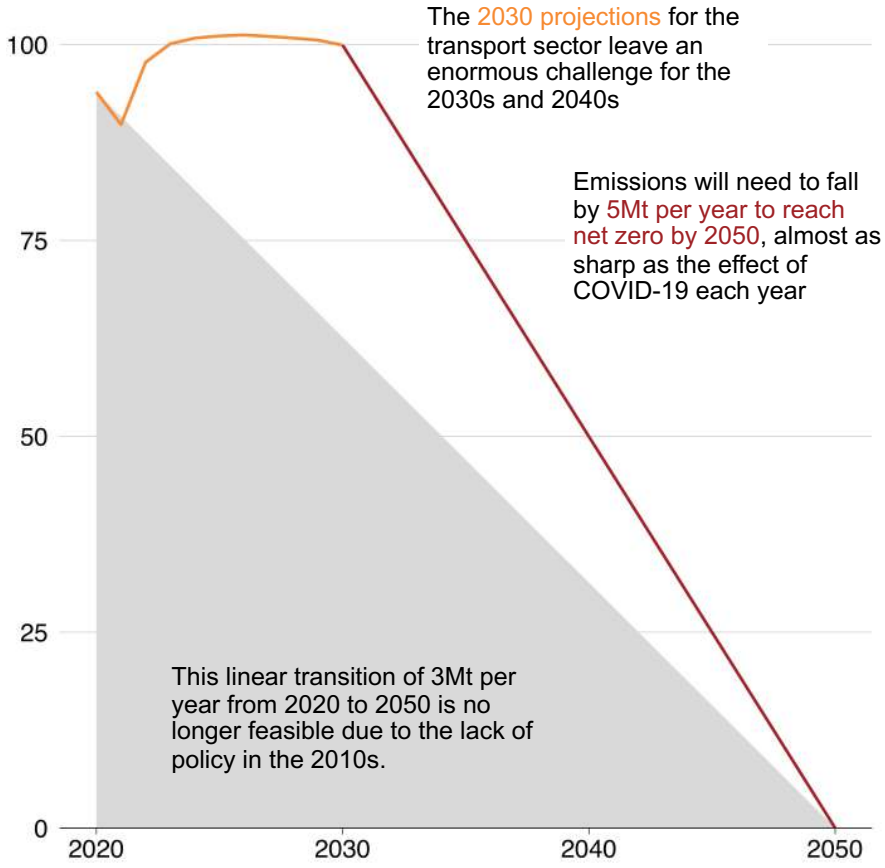
2 Where we are today in the transport sector

Transport sector emissions come from several sources. These include road vehicles such as passenger cars, light commercial vehicles, trucks, buses, and motorcycles. They also include domestic aviation (but not international flights) for both freight and passengers, rail transport where this is not electrified, and water-based transport of all sorts.

Annual emissions from transport grew from 82 million tonnes in 2005 to 101 million tonnes in 2019. They fell by 7 million tonnes in 2020 due to effects of the COVID-19 pandemic, but are expected to rebound, plateauing at 100 million tonnes per year by 2030. The lack of progress expected this decade is due to the fact so many emissions are already locked in. For instance, it takes more than 20 years to replace the light vehicle fleet; even if every car sold from tomorrow was zero-emissions, less than 40 per cent of the fleet would be zero-emissions by 2030.[7] It will take time to lift zero-emissions vehicle sales from less than 1 per cent today to 100 per cent, and this significantly constrains how much emissions reduction is possible this decade.[8]

To reach net zero by 2050, transport emissions will need to decline by 5 million tonnes every year in the 2030s and 2040s (Figure 2.1).[9] That's

Figure 2.1: The transport sector is unlikely to make much progress this decade, and will need transformative action in the 2030s and 2040s
Emissions per year (millions of tonnes)



Note: Emissions are 'carbon-dioxide equivalents'.

Source: Grattan analysis of DISER (2020a).

7. 'Zero-emissions' here means zero tailpipe emissions, which are the emissions counted in the transport sector. Electricity generation for electric vehicles or hydrogen production for fuel cell electric vehicles can create emissions in other sectors: this is explained further in Box 2 on page 15.
8. If demand for transport falls (as has happened as a result of the COVID-19 pandemic), then greater emissions reduction in the near term is plausible, but the overall transport task is expected to grow in line with population: DISER (2020b, p. 9) and Graham and Havas (2021, p. 36).
9. The trajectory of actual emissions is unlikely to be a straight line, because technological change tends to happen in fits and starts. But a straight-line trajectory is useful for assessing policy progress: if the actual trajectory drifts too far from it, the only way to bring it back is through abrupt and disruptive change.

almost as sharp as the impact of COVID-19 on the sector, but repeated year-on-year.

Such progress may be possible, but taking this path would mean emitting 40 per cent more emissions than if steady progress were to be made from now to 2050. Yet linear progress would require cuts of 3 million tonnes per year this decade, and Australia cannot realistically achieve this because of a lack of policy over the past decade. To avoid making the same mistake, Australia needs to spend the 2020s setting up the policies to ensure rapid decarbonisation is achieved in the 2030s.

And the faster progress is made in the 2030s, the easier it will be in the 2040s. To ensure Australia gets on track for this transition, we should focus on tackling large emissions sources with technologically-mature solutions, the most obvious of which is cars.

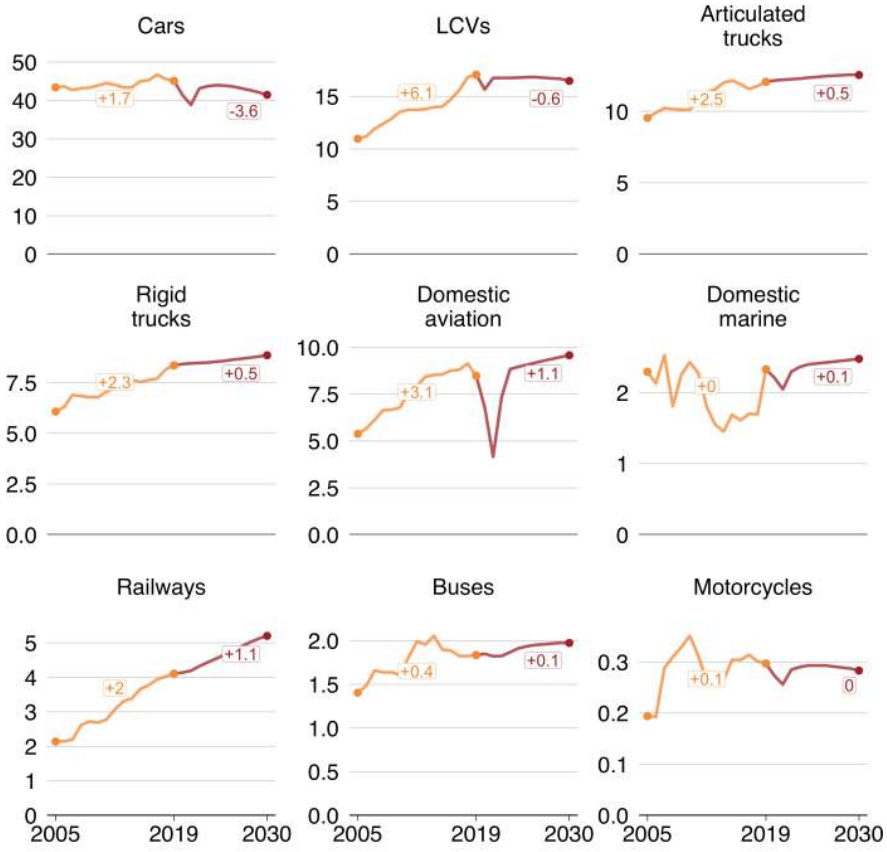
Policy from all tiers of government is needed – the federal, state and territory, and local governments each have responsibility for parts of the transport network. Currently, there are no Federal Government policies to reduce transport emissions at any significant scale; the Safeguard Mechanism covers barely a tenth of the sector's emissions.[10]

2.1 Transport emissions are mostly from cars

Growth in transport emissions is largely driven by growth in population. Figure 2.2 shows past and projected emissions for different types of transport.

Light vehicles (cars and light commercial vehicles combined) dominate: 62 per cent of total transport emissions in 2019, and 12 per cent of Australia's total emissions.[11] 'Light commercial vehicles' are not always light or used for commercial purposes; this group includes the two

Figure 2.2: Car emissions are expected to fall slightly, but freight and aviation emissions are expected to increase
Emissions per year (millions of tonnes)



Notes: LCVs = light commercial vehicles. Emissions are 'carbon-dioxide equivalents'.
Source: Grattan analysis of DISER (2020a).

10. CCA (2020, p. 100).
11. Grattan analysis of DISER (2020a).

best-selling cars in Australia, the Toyota HiLux and Ford Ranger.[12] Policies should consider light vehicles as one group, because motorists switch between the two, and many households own one of each.

Rigid and articulated trucks together are the next largest source: 20 per cent of total transport emissions in 2019.[13] Again, these should be considered together because they perform the same activity (road freight). Articulated trucks are much more common on inter-city routes; rigid trucks are more common within cities.[14]

Domestic aviation accounts for less than a tenth of transport sector emissions.[15] The remainder is made up of small sources: diesel-powered trains, domestic shipping and watercraft, buses, and motorcycles.

Chapter 3 identifies the main barriers to faster emissions reductions in the light vehicle fleet, and nominates the policies needed to ensure rapid progress over the next few decades. Chapter 4 proposes longer-term strategies to ensure Australia can bring down emissions elsewhere in the transport sector by deploying the right technologies as they become viable.

12. Nicholson (2021).
13. Articulated trucks are those where the truck can be detached from the trailer, and include semi-trailers, B-doubles, and road trains.
14. ABS (2020a, Table 11).
15. Based on pre-pandemic values from 2019.

3 What governments should do about light vehicles

The light vehicle fleet is responsible for more than 60 per cent of Australia's transport emissions, and only modest improvements are projected to 2030. Yet zero-emissions vehicles (overwhelmingly battery electric vehicles, but also fuel cell electric vehicles) exist today, and are getting cheaper. To decarbonise the transport sector by 2050 without major disruption, all light vehicles sales should be zero-emissions by about 2035. Government action will be necessary to ensure more people switch to zero-emissions vehicles.

By removing obstacles to people buying zero-emissions vehicles, governments can hasten the fleet's transition and save more of the emissions budget for trucks, trains, planes, and ships, where the technological solutions are less mature.

Governments should remove inefficient taxes on zero-emissions vehicles, but hold off on providing additional upfront subsidies for now – or at the very least, target them at the lower end of the market. Governments also need to facilitate the infrastructure necessary for these vehicles (notably charging points for electric vehicles), via regulations and, in some instances, co-investment with the private sector.

Government should aim to phase out the sale of new petrol and diesel light vehicles by setting a national fleet emissions standard that tightens to zero over the next 14 years.

3.1 The light vehicle fleet is projected to make little progress on emissions between now and 2030

Australia today has about 18 million light vehicles, up from 14.7 million in 2010.[16] And Australians today are driving bigger, heavier cars than they were a decade ago.[17] Light vehicle emissions have increased by 14 per cent since 2005.[18]

The Federal Government projects that the growth in light vehicle emissions will drop off between 2020 to 2030, due to fuel switching – especially from petrol to battery-electric – and more fuel-efficient vehicles. Light vehicle emissions in 2030 are projected to be 7 per cent lower than the pre-COVID levels in 2019, but higher than in 2020. On these projections, electric and fuel cell vehicles will make up only 7 per cent of the light vehicle fleet and 26 per cent of new sales by 2030.[19]

These figures do not include NSW or Victoria's targets of 50 per cent of all sales coming from zero-emissions vehicles by 2030.[20] Nevertheless, they lag well behind projections for other countries,

16. ABS (2011) and ABS (2020b). Light vehicles include passenger vehicles (about 80 per cent of the total) and light commercial vehicles, but not motorcycles.
17. NTC (2020, p. 23). This trend is also evident globally, with SUV (sport utility vehicle) sales growing in major markets including the US, Europe, China, and India at the expense of smaller cars: US EPA (2021, p. 15) and IEA (2019, pp. 150–151).
18. Based on 2019 pre-pandemic figures: DISER (2021a, pp. 55–58).
19. Both battery electric vehicles and hydrogen fuel cell vehicles can be zero-emissions vehicles (Section 3.2 on the following page); the Government projects about seven times more battery electric vehicles than hydrogen fuel cell vehicles by 2030: DISER (2020a, pp. 29–32). The Government's projections include plug-in hybrids in their total, which are not considered zero-emissions in this report: Box 2 on the next page.
20. Perrottet et al (2021); and DELWP (2021).

where a combination of phase-out dates, emissions standards, and subsidies are accelerating the move to electric vehicles.[21]

There is a significant opportunity today for Australian governments to create momentum for faster emissions reductions in transport in the 2030s. Action today can preserve more of the carbon budget for harder-to-abate transport tasks, and avoid locking in a high-emissions fleet that would require costly or draconian measures in the 2040s to eliminate.

3.2 Australia needs to switch to zero-emissions vehicles

To reach net-zero emissions in the transport sector by 2050, emissions need to fall dramatically. The light vehicle fleet should be close to zero carbon by 2050, and the rest of the sector should be well on its way. To reach and stay at net zero, any remaining emissions will need to be offset until the entire sector is zero emissions. But offsets (such as tree-planting) are finite and are likely to be costly due to competing demand from other sectors.[22] It is most efficient to use them only for the hardest-to-decarbonise parts of the transport sector, such as aviation.

Therefore, if Australia is to reach net zero by 2050 at low cost, it is inevitable that the future light vehicles fleet will be almost entirely made up of zero-emissions vehicles (see Box 2). Fuel-efficient petrol and diesel vehicles (including hybrids) are not zero-emissions, and will need to be phased out.

This does not need to happen overnight; consumers, guided by policy incentives, will make choices that best suit their situation. There are

21. The International Energy Agency (IEA) projects electric vehicles will make up at least 36 per cent of sales in Europe by 2030, and 34 per cent in China: IEA (2021b). BloombergNEF is much more bullish, predicting more than half of sales will be electric vehicles by 2030 in these regions, with slower uptake in Australia than the global average: BloombergNEF (2021a, Figure 5).
22. Wood and Ha (2021, p. 36).

Box 2: What counts as a zero-emissions vehicle?

About 98 per cent of Australia's light vehicles burn petrol or diesel in internal combustion engines, emitting carbon dioxide in the process. Less than 2 per cent of light vehicles run on liquefied petroleum gas, compressed natural gas, or accept multiple fuel types.[a]

Zero-emissions vehicles typically use electricity to power the vehicle, rather than burning a fuel.[b] The source of electricity is either a battery or a fuel cell. Batteries are charged from an external power source; fuel cells instead make electricity by extracting the energy of a zero-carbon fuel – typically hydrogen – without burning it.

Hybrid vehicles have batteries and an internal combustion engine. If the vehicle can be charged externally, it is a plug-in hybrid. Plug-in hybrids can be used in a zero-emissions way for short trips, but need to run on petrol or diesel for longer journeys. These are not considered zero-emissions vehicles in this report.

Battery electric vehicles and hydrogen fuel cell vehicles may be zero-emissions to run, but they can have upstream emissions depending on how the electricity or hydrogen is made. These emissions will be counted in Australia's electricity or industrial sectors, rather than transport. They should fall over time as all sectors decarbonise.

a. ABS (2020b). In this report, 'petrol and diesel vehicles' is used as a catch-all phrase for any vehicle that produces carbon emissions when used.
b. It is also possible to run an internal combustion engine vehicle on hydrogen. Burning hydrogen in air creates no carbon dioxide, but it can create other emissions (such as nitrogen oxides) and is much less efficient than using a fuel cell to convert the hydrogen to electricity: AFDC (2021). Vehicles running on other renewable fuels can also be carbon neutral, despite producing tailpipe emissions: see Box 3 on page 33 for details.

barriers to the adoption of zero-emissions vehicles today, such as upfront cost and worrying about access to charging (Section 3.3 on the following page). In the immediate term, zero-emissions vehicles might appeal most to consumers looking to replace just one of their family's vehicles with a cheap-to-run electric model for day-to-day use, while keeping a petrol/diesel vehicle for long-distance trips.[23] If effective policy reduces these barriers, so that more affordable and more versatile zero-emissions models become available and that complementary infrastructure (such as charging stations) is rolled out, then zero-emissions vehicles will increasingly appeal to a wider share of Australians. The number of drivers with no reasonable alternative to a petrol/diesel vehicle will steadily fall.

There are many more battery electric vehicles in production and on the roads globally than fuel cell electric vehicles, and on most projections it is battery electric vehicles that will dominate the light vehicle fleet in Australia.[24] The question is when. To decarbonise virtually the entire fleet – not just new sales – by 2050, requires government action to boost the uptake of these zero-emissions vehicles.[25] Crucially, all sales of new vehicles should be zero-emissions models from around 2035 (see Section 3.4.3 on page 22).[26]

Moving from 26 per cent of sales in 2030 (the Federal Government's projections) to 100 per cent in 2035 does not appear very likely: that's a 74 percentage point rise over just five years. Market researcher BloombergNEF publishes forecasts of electric vehicle uptake driven by technology and market forces alone, without additional policy or regulation; in its analysis, no major economy achieves near-100 per cent electric vehicle sales by 2035, nor does any see a 74 percentage point increase in sales over just five years.[27]

Relying on market forces alone to decarbonise Australia's light vehicle fleet is therefore a risky strategy that could well lead to millions more petrol and diesel models on the road in 2050. On the other hand, faster progress this decade to get us well beyond 26 per cent of sales by 2030 will make it easier to reach 100 per cent by 2035 and keep at least the light vehicle fleet on track for net zero.

There are other ways to reduce emissions from the light vehicle fleet, but these won't fundamentally change this conclusion. For example, Australians could drive less, or switch to public transport or active transport (walking and cycling). But these behaviour changes alone cannot be expected to get the sector close to net zero by 2050; a doubling of public transport use would still leave a huge number of cars on the roads, while also requiring major investment in public transport infrastructure.[28] Renewable petrol made from biomass or other non-fossil carbon sources is technically possible, but more expensive to produce than convention fossil fuel-based petrol (see Box 3 on page 33 for more detail). Australia's limited biomass resources are probably better directed towards higher-value fuels in harder-to-decarbonise areas such as aviation.

23. 56 per cent of Australian households have two or more vehicles: ABS (2017).
24. Graham and Havas (2020), BloombergNEF (2021a) and IEA (2021a, p. 134). Fuel cells seem a more likely solution for heavy vehicles, and this is discussed further in Chapter 4.
25. Martin (2021) and BloombergNEF (2021a).
26. Either that, or many petrol/diesel vehicles will need to be scrapped before the end of their useful lives: this is known as 'asset stranding'. See IEA (2021a) and BloombergNEF (2021a).
27. BloombergNEF (2021a, Figure 5).
28. Many public transport investments may well be justified on cost-benefit basis, and might reduce transport emissions, but these are not considered in this report.

3.3 Barriers to progress

3.3.1 Australians have few electric vehicle models to choose from, and those that are available tend to be expensive

Electric vehicles made up just 0.7 per cent of sales in Australia in 2020,[29] compared to 2 per cent in the US, 3 per cent in New Zealand, 11 per cent in the UK, and 75 per cent in Norway.[30] Hydrogen fuel cell vehicles are virtually non-existent in Australia (beyond a limited number of trials), partly due to the lack of hydrogen refuelling options.[31]

Australia stands alone among OECD countries in not having vehicle fuel efficiency and emissions standards, which have proven useful at reducing fleet emissions over time in other countries.[32] Australia has a voluntary scheme, which aims to achieve an average annual emissions reduction between 2020 and 2030 of 4 per cent for passenger cars and light SUVs (sport utility vehicles), and 3 per cent for heavy SUVs and light commercial vehicles.[33] In 2020, only about a third of manufacturers selling vehicles in Australia outperformed the standard in each vehicle class.Of the top 10 most popular brands, only one met its target in both vehicle classes.[34]

To some extent, because all new light vehicles are imported, Australia can 'free ride' on other countries' efforts to improve efficiency. But some automakers cite Australia's lack of any effective fuel efficiency or emissions standard as the main reason they send their lowest-emissions models to markets other than Australia.[35]

29. Electric Vehicle Council (2021).
30. IEA (2021b). These figures include plug-in hybrid electric vehicles, but these were a minority of the total electric vehicle sales in each country.
31. Dowling (2021).
32. Mortimore (2019).
33. FCAI (2020a).
34. Grattan analysis of FCAI (2020b).
35. Purtill (2021); and Allen (2021).

Australians have fewer than 30 electric vehicle models to choose from, a smaller range than in the UK, EU, or US.[36] Australians spend roughly $40,000 on average on a new car,[37] but just three electric vehicle models retail for less than $50,000.[38] Second-hand models remain scarce, with just 136 listed on Australia's largest online marketplace, out of more than 100,000 used vehicles.[39]

The price premium for battery electric vehicles is expected to fall, particularly as batteries become cheaper to manufacture.[40] But the crossover point – when the upfront cost of a battery electric vehicle is lower than an equivalent-performance petrol/diesel vehicle – is still some years away.[41]

Some say Australia's higher uptake of hybrid electric vehicles indicates that Australians prefer these rather than electric vehicles.[42] But it is uncertain how many hybrid buyers would prefer an electric vehicle but have not purchased one because they are not readily available.[43] And although hybrid vehicles have lower emissions than much of the light vehicle fleet today, a significant shift towards hybrids remains inconsistent with a target of net-zero emissions by 2050 (Figure 3.1 on the next page).

36. Kurmelovs (2021). By the end of 2021, 29 models are expected to be available in Australia: RACWA (2021).
37. Based on survey data of at least 2,600 new car owners: Birot (2020).
38. RACWA (2021).
39. Based on observation on 2 June 2021: carsales.com (2021).
40. BloombergNEF (2021b, p. 25).
41. BloombergNEF estimates that different light vehicle classes will reach cost parity between 2025 and 2027 in Europe: BloombergNEF (ibid, p. 26).
42. A. Taylor (2021).
43. While 53 per cent of drivers would seriously consider a hybrid for their next car, 39 per cent would consider an electric model – a relatively small gap compared to the difference in actual sales: Roy Morgan (2021).

3.3.2 For people willing to buy a battery electric vehicle, charging it can be a problem

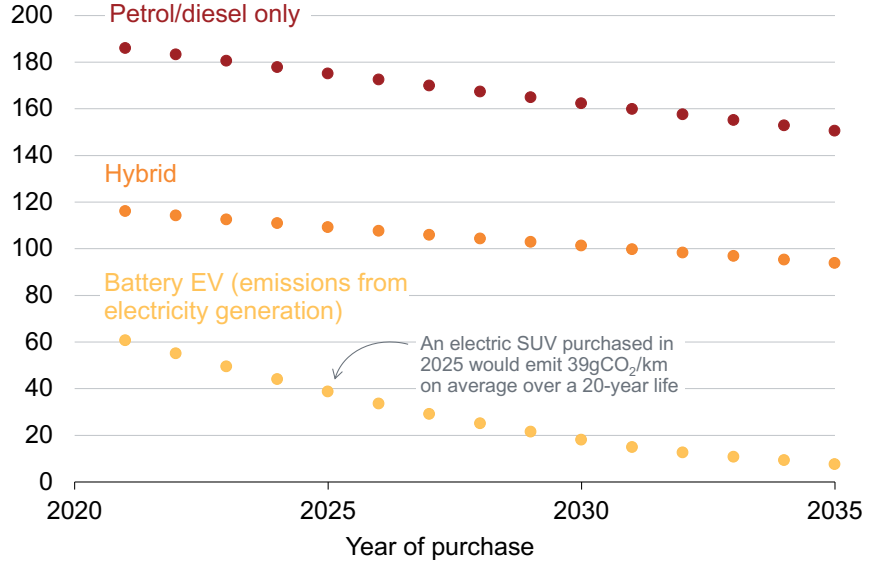
Most car trips in Australia are short. About 99 per cent of people who drive to work travel less than 100km to get there[44] – well within the range of a typical electric vehicle battery.[45] It seems likely that most battery electric vehicle drivers would charge their car at home, or potentially at work if a car space is provided, rather than needing to rely on widespread public charging stations.[46] Charging availability is a 'chicken and egg' problem: worry about where to charge is the single most cited factor in discouraging purchase of an electric vehicle,[47] but it is difficult to justify significant investment in charging infrastructure when vehicle numbers are so low.

People who live in apartments, who rent, or who do not have off-street parking may find it difficult to charge a battery electric vehicle at home. Unless these access issues are solved, electric vehicles may struggle to grow beyond about 60 per cent of the fleet.[48]

3.4 Policies to accelerate Australia's switch to zero-emissions vehicles

Governments should introduce policies to overcome three problems: the cost of switching to a zero-emissions vehicle; the lack of infrastructure that zero-emissions vehicles require; and the lack of zero-emissions vehicle models available to Australians.

Figure 3.1: Lifetime operating emissions for a battery electric vehicle are lower than for comparable internal combustion engine vehicles
Average fuel and electricity emissions over 20-year vehicle life (gCO_2-e/km) for three large SUVs



Notes: The models in this diagram are comparable large SUVs, each with towing capacity of 1,500kg or more: the Toyota RAV4 (petrol), Toyota RAV4 (hybrid), and Tesla Model X (electric). Driving emissions for the petrol and hybrid vehicles purchased in 2021 are taken from the fuel life-cycle emissions intensity reported in the Green Vehicle Guide (2021), which includes scope 3 emissions from fossil fuel production. These values may underestimate real-world emissions, as noted in ABMARC (2017). For cars purchased in subsequent years, emissions intensity is assumed to fall 1.5 per cent per year. No additional efficiency gains are assumed for new electric vehicles. Emissions for the battery electric vehicles are calculated from the electricity use per kilometre reported in Green Vehicle Guide (2021), multiplied by the average electricity emissions intensity in the National Electricity Market (NEM) over the 20 years from purchase date. NEM emissions intensity is assumed to decline over 2021-2042 according to AEMO's Step Change Scenario, and then linearly to zero emissions by 2050: AEMO (2020a). Electricity emissions intensity includes scope 3 emissions from fossil fuel production, as noted in GHD (2018), the source of emissions data used in AEMO (2020b).

Sources: Grattan analysis of the above references, Toyota (2021), and Tesla (2021).

44. Grattan analysis of ABS (2017).
45. Energeia (2018, p. 4).
46. Current estimates are that at least 80 per cent of electric vehicle charging is done at home: Electric Vehicle Council (2020, p. 66).
47. Ibid (p. 17).
48. Graham and Havas (2020, p. 50) estimate a maximum market share of 57 per cent for long-range electric vehicles in their Central scenario, where public and private charging access remains a key barrier to electric vehicle use.

In general, these policies should remove barriers and inefficient taxes, while creating flexibility for future governments to move faster in line with emissions targets. They should avoid locking in substantial light vehicle emissions beyond 2050.

The ideal suite of policies in the near term would include scrapping inefficient taxes on zero-emissions vehicles; changing the National Construction Code to ensure buildings are ready for electric vehicles; and introducing a vehicle fleet emissions standard that tightens to zero emissions by 2035, to phase out the sale of new petrol/diesel light vehicles. A summary of the Commonwealth and states' existing policies is listed in Table 3.1 on the following page.

3.4.1 Make zero-emissions vehicles cheaper by scrapping inefficient taxes

The Federal Government should scrap import duties on zero-emissions vehicles, and exempt them from luxury car tax until 2030. Import duties were intended to protect Australian auto manufacturing. With the decline of that industry, they are no longer fit-for-purpose, and are increasingly being removed via free trade agreements. Vehicles from countries including Japan, Korea, and the US already attract zero import duty due to free trade agreements.[49] Removing import duty on all zero-emissions vehicles would give Australians a greater range of choice and save consumers about 5 per cent of the upfront vehicle cost.[50]

Exempting zero-emissions vehicles from luxury car tax would reduce the cost of vehicles above the luxury car tax threshold of $79,659, which today are taxed an additional 33 cents for every dollar above the threshold.[51] This would make many of the models that are available in Australia cheaper immediately. The Federal Government should review the luxury car tax closer to 2030 and decide on its future as part of a broader consideration of tax reforms.

State governments should remove motor vehicle stamp duty for all zero-emissions vehicles. This would reduce the cost of new electric vehicles by up to 4 per cent in Victoria and Queensland, and up to 6.5 per cent in Western Australia.[52] It would also help to stimulate the second-hand market for zero-emissions vehicles. The ACT Government has already removed stamp duty on new zero-emissions vehicles, and the NSW Government will remove it for all zero-emissions vehicles under $78,000 from September 2021.[53] Motor vehicle stamp duty is an inefficient tax, especially applied to new vehicles.[54]

The grounds for direct subsidies, rather than the elimination of inefficient taxes, are weaker. Zero-emissions vehicles are still in the 'Innovator' phase of the technology adoption curve (Figure 3.2 on page 21), which means they are generally purchased by people who are less sensitive to price and more motivated by the status and excitement that comes with new, greener technology.[55]

However, if governments want to subsidise zero-emissions vehicles, it would be more equitable to target these subsidies towards lower-priced models, or towards light commercial vehicles that deliver the performance required for Australian conditions. This would encourage auto manufacturers to give priority to cheaper and higher-performance models for the Australian market, boosting the potential market share of zero-emissions vehicles.

49. DFAT (2015), DFAT (2014) and DFAT (2005).
50. For countries without a free trade agreement, import duties are generally 5 per cent of the customs value of a vehicle: ABF (2021).
51. This threshold is the 'fuel-efficient vehicles' threshold, which is higher than the normal threshold: ATO (2021).
52. VicRoads (2021a), Queensland Government (2019) and WA DoT (2021).
53. ACT Revenue Office (2021); and Perrottet et al (2021).
54. Nassios et al (2019, p. 15).
55. Rogers (2003).

Table 3.1: Existing policies on zero-emissions light vehicles

Measure	Cth	NSW	Vic	Qld	WA	SA	Tas	NT	ACT
Sales or uptake target	None	More than 50% new car sales by 2030; 'vast majority' new car sales by 2035	50% new light vehicle sales by 2030	None	None	'Want all new passenger vehicles sold in South Australia to be fully electric by 2035'	None	None	None
Tax break	None	Stamp duty waiver for EVs under $78,000 (purchased from 1 September 2021)	Not EV-specific: luxury low-emissions vehicles avoid the luxury duty rates	Not EV-specific: hybrids and EVs pay lower duty rates	None	None	Two-year stamp duty waiver on new and secondhand EVs (election commitment)	None	Not EV-specific: stamp duty exemption for all new vehicles emitting less than 130gCO_2/km
Capital cost assistance	None	$3,000 rebate for the first 25,000 EVs under $68,750 sold from 1 September 2021	$3,000 rebate for 4,000 vehicles in first round; more than 20,000 subsidies in total	None	None	None	None	None	Interest-free loans up to $15,000
Free or discount registration	n/a	None	$100 discount on registration	Not specific to EVs	None	None	Two years free for car rental companies	Not specific to EVs	Two years free registration
Investment in charging infrastructure	Yes	Yes	Yes	Yes	Yes	Yes	Yes	None	Yes
Government fleet use	None	Transition to EVs where feasible; target for fully electric fleet by 2030	400 vehicles in VicFleet to be replaced by zero-emissions vehicles by 2023	Increase the number of electric vehicles in its fleet from 18 in 2018 to 288 by 2022	25% by 2025-26	Require new government fleet vehicles to be plug-in electric models where fit-for-purpose and cost effective	100% electric vehicles by 2030	None	All newly leased ACT Government fleet passenger vehicles are zero-emissions vehicles from 2020-21, where fit-for-purpose
Road user charge	n/a	Phased in from 1 July 2027 or earlier if EVs make up 30 per cent of all new vehicle sales	Applies from 1 July 2021	None	None	Applies from 1 July 2022 (pending review)	None	None	None
Building readiness requirements	None	Relevant regulations to require new buildings and precincts are constructed and wired to be 'EV ready' (no date given)	Considering non-statutory measures to future-proof buildings while the National Construction Code is reviewed	None	Supports amendments to the National Construction Code to include a requirement that new buildings are EV-ready	None	None	None	Amend the Parking and Vehicle Access General Code to promote uptake of zero-emissions vehicles
Share of fleet	–	29%	26%	21%	11%	7%	3%	1%	2%

Sources: DISER (2021b), DPIE (2021a), DPIE (2021b), Perrottet et al (2021), DELWP (2021), VicRoads (2021a), VicRoads (2021b), VicRoads (2021c), Solar Victoria (2021), Queensland Government (2019), Queensland Government (2017), Queensland Government (2018), DWER (2020), DEM (2020), Sutton (2021), Gutwein (2020), Tasmanian Liberals (2021), EPSDD (2020), Actsmart (2021) and ABS (2020b)

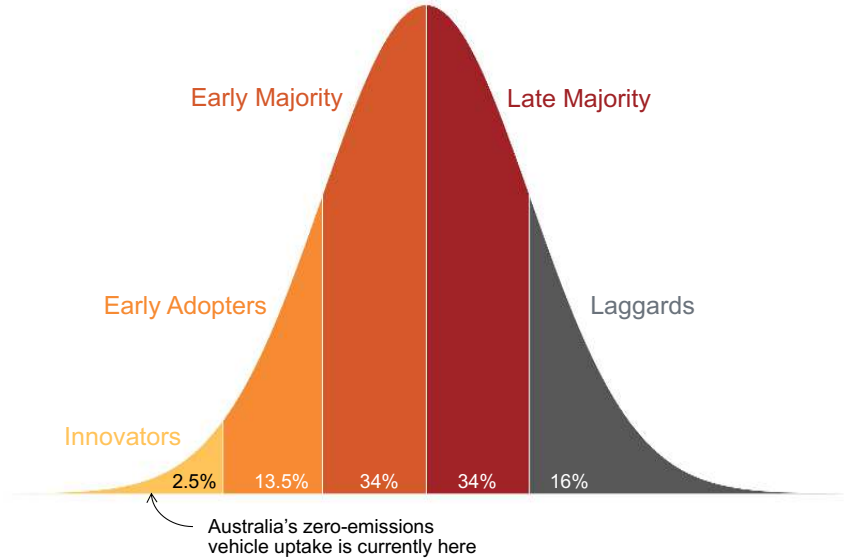
Studies show consumers are more sensitive to upfront than ongoing costs, and therefore reducing the upfront purchase cost is likely to be more effective at influencing consumer choice than providing an ongoing subsidy or benefit (for example, by offering discounted registration, free parking, or access to bus lanes).[56]

This finding also suggests governments should not hesitate to introduce road-user charging for zero-emissions vehicles, as has been legislated in Victoria and is under consideration in South Australia and NSW (see Table 3.1 on the preceding page).[57] Emissions are not the only cost that cars impose on society; a per-kilometre road-user charge helps to ensure that drivers pay for their access to roads, which are an expensive public resource. If the complementary policies to boost zero-emissions vehicle uptake recommended in this report were adopted, there would be no reason to hold off on introducing a road-user charge for drivers of those vehicles. Alternatively, state governments could partially or fully replace motor vehicle registration for zero-emissions vehicles with road-user charges.

3.4.2 Make it easier for people to charge electric vehicles

The National Construction Code (NCC) should be amended to require new houses and apartments to include electrical cabling to car spaces and garages that could support later installation of vehicle charging points. This requirement could also apply to significant alterations and additions to houses and apartments. Doing the electrical work for a charging point is much cheaper at the time the building is built or added to, rather than later.

Figure 3.2: The technology adoption curve



Source: Grattan analysis, adopted from Rogers (2003).

The Australian Building Codes Board is currently considering this amendment at the request of Energy Ministers.[58] If implemented in the current round of revisions to the NCC, this policy alone would ensure that by 2035, about a quarter of homes would have charging access, and at lower cost than if retrofitting had been required.[59] Waiting for the 2025 round of revisions would reduce this proportion to about 18 per cent.

56. Energeia (2018).
57. Nationally consistent road-user charging would be preferable, but is likely to require one state to take the lead in legislating, with other states then mirroring that legislation in their own statute books.
58. ABCB (2021).
59. By 2035, about a quarter of dwellings will have been built since 2022 (the earliest year the new standards could apply), based on development trends over the past decade: Grattan analysis of ABS (2021a) and ABS (2021b). This figure will be lower if dwelling construction slows due to weaker population growth over the next few decades: Treasury (2021, pp. 13–14).

The section of the NCC that governs multi-storey carparks should also be amended, to require electrical cabling that would in future support a minimum ratio of charging points to parking spaces in new car parks and commercial buildings.

Looking further into the future, the prospect of many battery electric vehicles being charged at the same time could cause electricity demand surges – much like air-conditioning loads on hot days do now. To protect against this, tariff reform and the installation of charging infrastructure will need to be coordinated. Car owners and electricity networks would benefit if vehicles were charged when there's excess electricity capacity and energy is cheap, such as during the middle of the day. But this will happen only if the price signal is right and if charging points are located where the cars are in the middle of the day – such as at workplaces and public car parks.

Making sure 'smart' charging points are widely distributed so that the vehicle charging load can be managed efficiently would be a prudent move. Governments should plan for this early to avoid a repeat of the unintended consequences for the electricity grid caused by the rapid expansion of rooftop solar.[60]

3.4.3 Create an effective mechanism to reduce light vehicle emissions, phasing out new petrol/diesel sales by 2035

Australia needs a policy mechanism to drive down emissions in the light vehicle fleet. This policy should encourage vehicle manufacturers to give Australians more low- or zero-emissions options. It should effectively phase out the sale of new petrol/diesel vehicles by 2035. A fleet emissions standard would be the most efficient policy to achieve this objective.

Phasing out the sale of new petrol and diesel vehicles by 2035 is crucial to avoid locking in emissions

Australian vehicles last more than 20 years on average.[61] And many vehicles last much longer – cars manufactured before 2000 are readily available on the second-hand market. This means that at least some of the petrol or diesel vehicles sold today could still be in use in 2050. If new petrol and diesel vehicles continue to be sold through the 2030s and 2040s, the fleet will be far from zero-emissions in 2050 unless government policy or a lack of petrol/diesel re-fuelling locations forces them to be scrapped before the end of their lives.[62]

In 2021, the International Energy Agency (IEA) published a roadmap to achieving global net zero emissions by 2050.[63] It recommended phasing out the sale of new petrol/diesel cars by 2035. Many major economies around the world have adopted this target or an earlier one, including the UK, Canada, Japan, and California.[64] If Australia moves more slowly, there will be a greater number of petrol/diesel cars on our roads by 2050, which means more emissions to offset or eliminate in pursuit of a net-zero goal. If governments are unwilling to impose potentially expensive offset liabilities on drivers post-2050, then they

60. AEMO (2020c, pp. 73–85).

61. The fleet turnover rate averaged 4.1 per cent per year over 2015-2020, suggesting an average lifespan of about 24 years across all vehicle classes (including heavy vehicles): ABS (2020b). Light vehicles tend to be younger (the current fleet has an average age of 10.1 and 10.6 for passenger and light commercial vehicles respectively, compared to 10.9, 15.7, and 12.0 for light rigid, heavy rigid, and articulated trucks respectively), so the average lifespan of a light vehicle is probably closer to 20 years. The IEA assumes an average lifespan of 17 years for passenger cars: IEA (2021a, p. 39).
62. As the vehicle fleet electrifies, it is expected that the number of petrol stations will decline: VACC (2017, p. 9).
63. IEA (2021a).
64. Johnson (2020), Scherer (2021), Landers and Tsuneoka (2020) and Newsom (2020). Japan would continue to allow hybrids to be sold from 2035, while the other jurisdictions would allow only zero-emissions vehicles.

may need a cash-for-clunkers-style program to force these cars off the roads.[65]

Phasing out the sale of new petrol/diesel cars is therefore crucial – but not sufficient – to avoid locking in emissions beyond 2050. A phase-out date would send the clearest possible signal to auto manufacturers that they need to give priority to supplying zero-emissions models suited to Australian conditions and consumer preferences. And giving motorists 14 years' notice of the end date would give them ample time to adjust their purchasing decisions. After 2035, motorists could continue to buy petrol/diesel light vehicles, but on the secondhand market.

The most efficient policy is a light vehicle emissions standard that tightens to zero emissions by 2035

The best way to phase out new petrol/diesel light vehicle sales by 2035 is via a national, mandatory fleet emissions standard. Designed well, this policy would boost consumer choice by giving Australians access to the most fuel-efficient models in the near term, while reducing emissions of the vehicle fleet over time.

It would work by the Federal Government setting an emissions standard that specifies an average emissions intensity target for all sales in a given year: e.g. 150g of carbon dioxide equivalent emissions per kilometre in 2023.[66] All cars sold in Australia already have a vehicle emissions rating; an emissions standard would require vehicle manufacturers to ensure the average across all their new vehicle sales was below the standard, or face a penalty proportional to their additional emissions intensity and number of cars sold.[67]

This is an effective policy because it directly targets the problem: it would encourage manufacturers to sell lower-emissions vehicles in the lowest-cost way across their sales base. Any additional cost to consumers of a lower-emissions vehicle would be partly offset, or in many cases outweighed, by lower running costs from better fuel efficiency.[68]

This policy would also preserve consumer choice, because in the short-to-medium term manufacturers could meet the standard by selling lower-emissions petrol/diesel vehicles or by selling zero-emissions vehicles, whichever they are able to produce, while still being able to sell higher-emissions vehicles.

The policy could be made more efficient still if manufacturers below the target received credits equal to the number of cars sold multiplied by their over-achievement, and those credits could then be sold to manufacturers who were over the target, to reduce their liability.

The emissions standard should be set for all light vehicles (including light commercial vehicles), and should tighten each year to reach zero by 2035, to effectively phase out new petrol/diesel light vehicle sales. The standard need not decline linearly, but it should reach zero

65. For example, CSIRO modelled a pathway to achieve zero emissions across the entire road transport fleet, using a 2040 phase-out date for the sale of all new petrol/diesel vehicles: Graham and Havas (2020, p. 70). But this pathway required scrapping rates to accelerate throughout the 2030s.
66. Australia's new light vehicle fleet (including light commercial vehicles) had an average intensity of 180.5g/km in 2019: NTC (2020, p. 11).
67. Vehicle manufacturers rather than individual dealerships should be responsible for meeting the standard, to reduce complexity: CCA (2014b, p. 57). The penalty should at a minimum reflect the cost of offsetting emissions above the standard across the fleet's life. The emissions ratings for new vehicles should be verified in real-world conditions: AAA (2021, pp. 6–7).
68. DIRD (2016, p. 96).

by 2035. The current voluntary standard is insufficient: it is too lax,[69] unenforceable,[70] and easily gamed by vehicle manufacturers.[71]

Although an emissions standard of 0g/km effectively phases out new petrol/diesel vehicle sales, it does not necessarily *ban* them – some could continue to be sold, with the manufacturer passing the penalty through to buyers.[72]

We do not recommend an all-carrot-no-stick emissions standard, where car makers are rewarded by governments for selling a fleet below the baseline but face no penalty for breaching the standard. This is just a subsidy to car makers that sell lower-emissions models. In this case, it would be more transparent to simply offer subsidies on the purchase price of lower-emissions vehicles, though that is not an approach we favour at this time for reasons discussed in Section 3.4.1 on page 19.

69. It aims to reduce emissions intensity of new sales over the next decade by just 4 per cent per year for light passenger cars and 3 per cent per year for larger SUVs and light commercial vehicles – a decline in emissions intensity of about 6g/km per year for each vehicle class, reaching 100g/km for light passenger vehicles and 145g/km for SUVs and light commercial vehicles by 2030: FCAI (2020a). To be consistent with achieving zero-emissions sales by 2035, the fleet emissions intensity would then need to fall by at least 20g/km for each of the subsequent five years.
70. There are no financial penalties for failing to meet the standard, and no financial incentives to outperform it.
71. Under the current voluntary standard, lower-emissions vehicles earn 'supercredits': any vehicle that has zero tailpipe emissions counts for 3 sales, while vehicles that have emissions less than 33 per cent of the standard count for 2, and vehicles under 66 per cent count for 1.5: FCAI (2020c). This allows brands with hybrid or zero-emissions models to meet the standard even if their true average emissions are well above the standard.
72. Governments may want to keep this option so that consumers who need or prefer petrol/diesel vehicles could still buy a new one in the late 2030s or early 2040s. But any emissions the vehicle produces after 2050 would need to be offset, which would require future policy to enforce.

Alternatives to an emissions standard are less effective or higher cost

The Federal Government has not introduced vehicle emissions standards despite repeated consultation on the matter.[73] Previous attempts were thwarted by several factors, one of which was the more stringent fuel standards that would be needed to accompany the emissions standard. It was claimed the extra costs of meeting these fuel standards would lead directly to local refinery closures.[74] But Australia has only two refineries now, both of which are receiving government assistance to produce low-sulfur petrol by 2024.[75]

If governments are unwilling to pursue vehicle emission standards, there are other options, but they are either less effective or more costly (Table 3.2 on the following page).

The first alternative is to introduce sales targets for zero-emissions vehicles, with penalties for non-compliance. NSW and Victoria have announced targets of 50 per cent of vehicle sales being zero-emissions by 2030, though without any enforcement mechanism. In the IEA's net-zero pathway, zero-emissions vehicle sales in advanced economies reach a 75 per cent share by 2030.[76]

Zero-emissions vehicle sales targets can be designed to phase out petrol/diesel vehicle sales by 2035 by simply setting a 100 per cent target for that year. But these sales targets are less efficient than an emissions standard: they will not reduce the emissions intensity of petrol/diesel sales between now and their phase-out. They will probably do less to boost consumer choice than an emissions standard. If implemented with a tradeable credit scheme (similar to the Large-scale Renewable Energy Target), then vehicle manufacturers without zero-emissions models or with few zero-emissions sales would need

73. DITRDC (2021a); and Smit et al (2019).
74. AIP (2017).
75. Morrison and A. Taylor (2021).
76. IEA (2021a, p. 20).

to purchase certificates from manufacturers that exceed the sale target. There are fewer ways for manufacturers to meet the target than under an emissions standard.

Another alternative is for the Federal Government to simply ban the import of petrol/diesel light vehicles beyond 2035. Or states could ban registration of new petrol/diesel light vehicles from 2035.[77] Around the world, an increasing number of jurisdictions are adopting phase-out dates, and many auto manufacturers have likewise made commitments to sell only zero-emissions vehicles in future.[78] But unless combined with a policy like an emissions standard, these policies would give governments little influence over the path to get there, and there may be less emissions abatement over the next 14 years than if an emissions standard were in place.

The lightest-touch policy would be for governments to use their own government fleet purchasing power to encourage better performance from manufacturers. Some state governments have already set targets for electric vehicles in their government fleets (see Table 3.1 on page 20); others should follow suit when fleet contracts are next renewed. Governments could also encourage better compliance with the industry-led voluntary standards for emissions reductions, by purchasing or leasing vehicles only from those brands which meet the standard, and purchasing only the lowest-emissions vehicles that meet the needs of the buyer. These policies could include not just the government fleet, but vehicles provided to government employees through salary packaging.

Lower-emissions government fleet purchases are a sensible action that governments can take immediately. But on their own, they will not

Table 3.2: Mandatory vehicle fleet emissions standards would be the best policy for systematically reducing light vehicle emissions
Comparing policies to ensure that new light vehicles are lower-emissions (the lighter the colour, the higher the score)

	Effective	Efficient	Simple	Flexible	Popular
Mandatory vehicle fleet emissions standards					
Zero-emissions vehicle sales targets					
Ban imports or registrations of new petrol/diesel vehicles					
Government fleet purchases are strictly low-emissions					
Legend	Lowest				Highest

Note: 'Effective' compares how much each policy gets the light vehicle fleet on track for net zero. 'Efficient' compares the relative cost of abatement for each policy. 'Simple' compares how administratively easy is it to implement. 'Flexible' compares how easy is it to adjust the policy or transition it into another policy. 'Popular' compares how politically easy it is to sell the policy.

77. There may be tiny niches where states grant exemptions from the phase-out if there are certain light vehicle transport tasks that zero-emissions vehicles are still unable to complete effectively at that time.
78. IEA (2021c); and Graham and Havas (2021, p. 44).

significantly bend the trajectory of the light vehicle fleet's emissions, or prevent Australia from locking in high levels of transport emissions beyond 2050.

Boosting zero-emissions vehicle uptake through policy is crucial for getting on track to net zero by 2050

Figure 3.3 on the following page provides an illustration of how policies such as a fleet emissions standard or zero-emissions sales targets could work to reduce the emissions of the light vehicle fleet. In this stylised example, government policy results in 75 per cent of vehicle sales in 2030 being zero-emissions vehicles (assumed to be battery electric vehicles), growing to 97 per cent by 2035 and 100 per cent by 2038.[79]

However, without accelerated scrapping of petrol and diesel vehicles in the 2040s, there are still a few million of them on the road in 2050. This means Australia has to offset a few million tonnes of emissions. If Australia's zero-emissions light vehicle uptake is slower, significantly more scrapping or offsetting will be necessary to meet governments' climate targets.

In the hypothetical scenario in Figure 3.3, tailpipe emissions from the light vehicle fleet would fall about 17 per cent from 2019 to 2030, compared to 7 per cent in the Federal Government's projections. This would reduce the transport sector's 2030 emissions by an additional six million tonnes, compared to the official projection.

79. This assumes that either vehicle emissions standards or zero-emissions vehicle sales targets are designed to phase out petrol and diesel vehicle sales by 2035, with some exemptions granted for a few years after that.

3.4.4 Keep looking for ways to remove barriers to faster progress

Governments should review the effectiveness of the above policies within three years and make changes where necessary. At that time, if governments want to make faster progress they may need to consider a large number of modest rebates to nudge price-sensitive consumers towards zero-emissions vehicles. Or the Federal Government may need to tighten the emissions standard more quickly. Governments should investigate whether these options represent low-cost abatement opportunities compared to fast-tracking other sources of abatement in the transport sector.

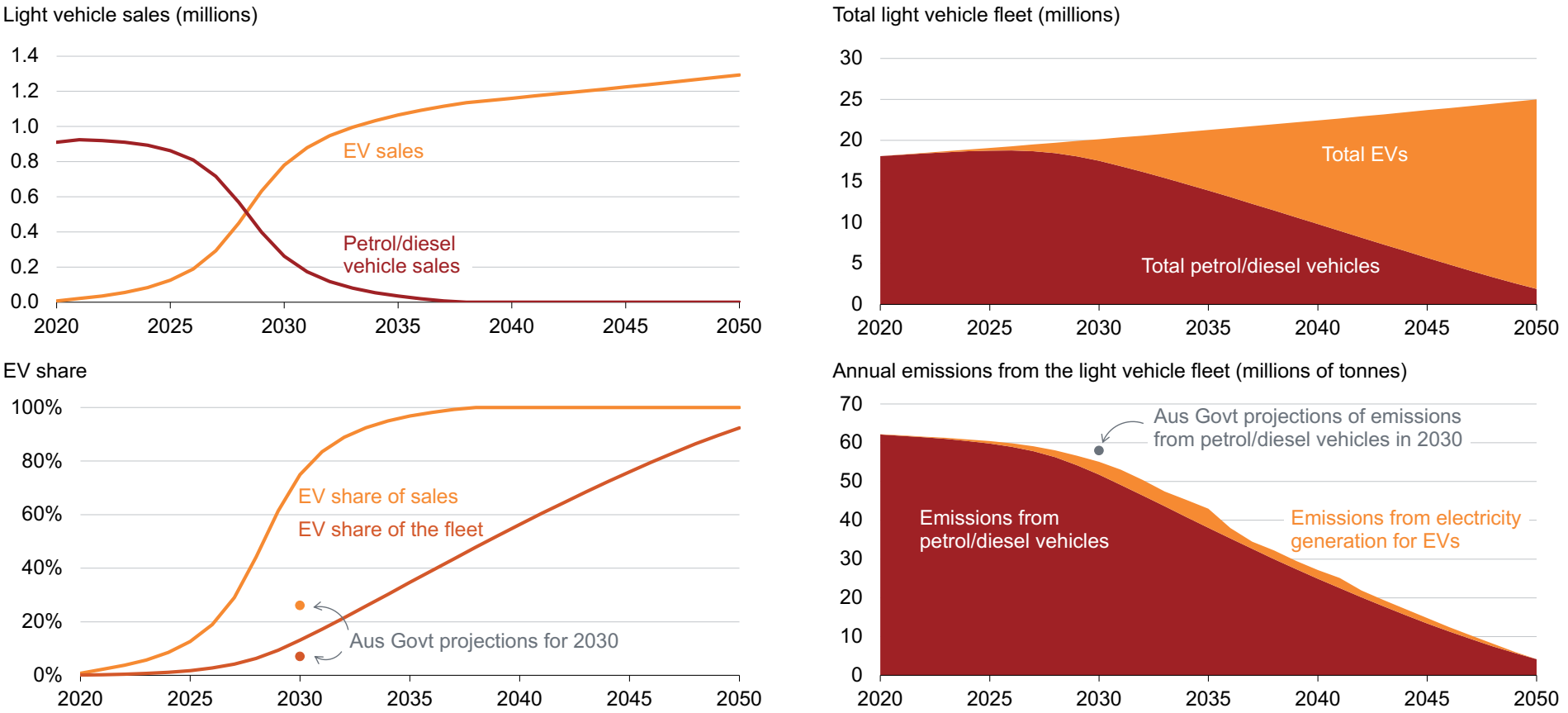
As more zero-emissions vehicles enter the fleet, some consumer segments will be saturated while others will emerge. For example, by the time zero-emissions vehicles make up 7 per cent of the fleet (the government projection for 2030), the technology will be in the 'Early Adopter' phase (Figure 3.2 on page 21). But as more consumers switch to zero-emissions vehicles, the remainder of the market will increasingly consist of those who lack the infrastructure to make the switch viable, such as renters, people without off-street parking, or residents of many existing apartment buildings.

Therefore, policies to remove these infrastructure barriers should be introduced, including:

- States mandating access to a power-point near any off-street car spaces as part of minimum rental standards for properties with off-street parking;[80]

80. Works required to comply with mandatory requirements in rental properties can be claimed as an immediate tax deduction, a decline in asset value, or a capital works deduction, depending on the nature of the works: ATO (2019). Deductibility should mitigate upwards pressure on rents.

Figure 3.3: Achieving 75 per cent electric vehicle sales by 2030 and near-100 per cent by 2035 would get the light vehicle fleet mostly on track for net zero, with just a few million petrol and diesel cars still on the road in 2050



Notes: Adoption curve is stylistic only. It shows 75 per cent of sales being electric in 2030 and 97 per cent of sales being electric in 2035, roughly in line with the recommended pathway in IEA (2021a). This analysis assumes all electric vehicles are battery electric vehicles, not plug-in hybrids or fuel cell electric vehicles; the Australian Government projections include plug-in hybrids in their total, however: DISER (2020a). Electricity emissions intensity is assumed to decline nationwide at the same rate as the National Electricity Market over 2021-2042, according to AEMO's Step Change Scenario, and then linearly to zero emissions by 2050: AEMO (2020a). EV annual energy consumption taken from AEMO (2020b). The annual emissions per petrol/diesel vehicle is assumed to fall 1.5 per cent per year, based on the 'High Tech Scenario' Assumption in DISER (2020a). 4.1 per cent of the vehicle fleet is scrapped each year, in line with the attrition rate over 2015-2020: ABS (2020b). Based on data from VicRoads (2020), one-fifth of the turnover is assumed to be due to random crashes, with the rest due to vehicle age.

Sources: Grattan analysis, including of the sources listed above.

- Local councils procuring or allowing the private sector to build on-street electric vehicle chargers in suburbs with very little off-street parking; and
- Governments assisting body corporates to retrofit a limited number of shared charging points in apartment or commercial building car parks, where it is not economic for the private sector to provide them.

For charging away from home, the Federal Government has already made proof-of-concept investments in fast charger networks (via the Australian Renewable Energy Agency, or ARENA), and most state governments have made some investment in charging networks.[81] Public charging infrastructure will need to respond to and support emerging consumer preferences. This infrastructure would ideally be provided under a commercial business model. However, it is also likely that some early barriers will not be able to be removed without government support.

Future government support should focus on areas where the private sector is unlikely to supply charging infrastructure, such as less-populated regional and rural areas, and lower socio-economic areas. To protect against over-investment or pork-barrelling, these investments should proceed only if robust assessment shows the benefits, notably reduced emissions, outweigh the costs.

81. ARENA (2021).

4 What governments should do about the rest of the transport sector

4.1 Heavy vehicles

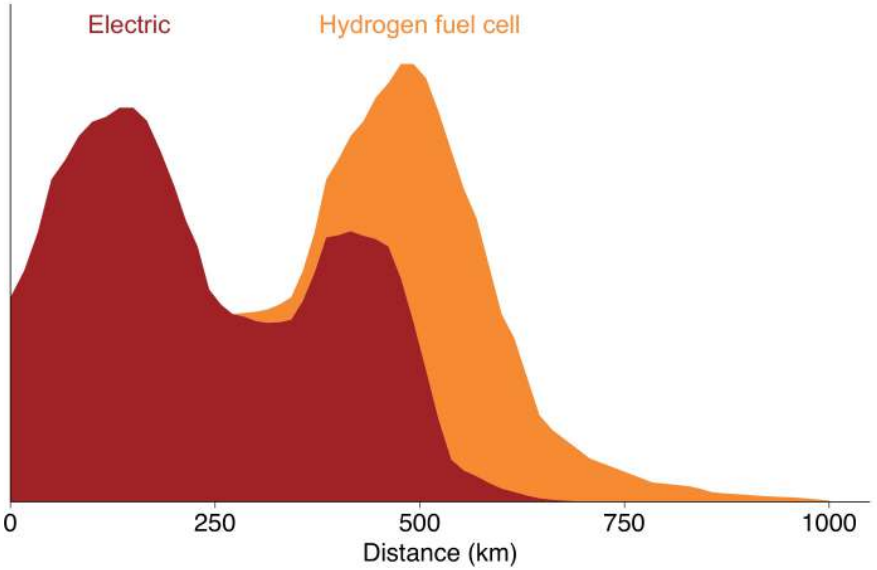
Heavy vehicles – trucks – made up 20 per cent of transport emissions in 2019, and these emissions have grown by 31 per cent since 2005.[82] The number of tonne-kilometres for articulated trucks has been growing steadily since the 1970s.[83]

The Federal Government projects this growth will slow between 2020 and 2030 due to improved freight efficiency and some lower-emissions technology uptake,[84] but the trend is still upwards – no emissions reductions are anticipated this decade.

Similar to light vehicles, the lifespan of heavy vehicles poses a challenge to reaching net zero. Technological solutions are emerging, but there is no clear 'winner' yet. The IEA expects that battery electric trucks may be most useful in urban environments, while hydrogen fuel cell trucks will dominate for longer-distance transport needs (Figure 4.1). Current models of battery electric trucks compare poorly to hydrogen trucks over long distances because the extra battery capacity required weighs more, reducing the vehicle's payload compared to an equivalent hydrogen fuel cell truck.[85] However, determining the best truck for the job requires understanding not just distances driven, but also geographical coverage, how predictable and repeatable routes are, and the number and length of breaks per trip or per day.[86] As well, battery density (electricity stored per unit of weight and volume) is improving, and over time hydrogen may lose some of its advantage.[87]

Figure 4.1: The IEA predicts that electric vehicles will dominate short-range trucking by 2050, with hydrogen fuel cell trucks for longer distances

Future distribution of trucking trip distance by fuel type



Source: Grattan analysis of IEA (2021a, p. 163).

While a few battery electric and hydrogen fuel cell trucks exist, they are some way from being commercially competitive.[88] Fuel costs, whole-of-life costs, and duty cycles are largely untested. Many of the barriers

82. Based on pre-pandemic values from 2019: DISER (2020a). Buses are discussed briefly in Section 4.3 on page 32.
83. BITRE (2020). Articulated trucks are those where the truck can be detached from the trailer, and include semi-trailers, B-doubles, and road trains.
84. DISER (2020a, p. 30).
85. Deloitte (2020, pp. 22, 58).
86. Shell (2021, p. 58).
87. Collins (2021).
88. For example, Volvo now offers a range of battery electric trucks in some countries, at higher cost than diesel models: Volvo (2021).

for electric and hydrogen trucks will be similar to those for light vehicles: availability of models, access to charging or refuelling infrastructure, and vehicle price.[89]

An additional barrier in Australia is the Australian design rules for heavy vehicles. These require heavy vehicles on Australian roads to be no more than 2.5m wide – narrower than is standard in the EU (2.55m) or US (2.6m).[90] As a result, many imported trucks must be made specially for the Australian market, or rebuilt here before registration.[91] This increases their cost, reducing the availability of lower-emissions, safer vehicles.[92] This regulation will stand in the way of swift adoption of zero-emissions trucks as these become commercially available.

There are three priorities for governments here. First, the heavy vehicle width limit should be increased from 2.5m to 2.6m to match the US.[93] This would enable Australia to import zero-emissions trucks designed for the EU and US markets (but adapted to be right-hand drive), giving freight operators many more options as these vehicles become cheaper and more widely available. Newer trucks also tend to be safer, and trucks wider than the existing 2.5m limit can be required to use additional road safety technology.[94]

Second, governments should support targeted trials of zero-emissions trucks tailored to understanding vehicle performance under Australian conditions and practices. Urban duty cycles are not likely to differ significantly from those in other countries, but longer-distance duty cycles are. Trials should therefore focus on hydrogen trucks, and should look beyond achieving fuel cost parity to understanding the best duty cycles and routes.

Third, a national renewable fuel standard for diesel, aviation, and shipping fuels (Section 4.4 on page 32) should be introduced, ideally by the Commonwealth. If development of zero-emissions vehicles is slower than expected, the long life of heavy vehicles means the fleet will remain dominated by internal combustion engines (and fossil fuels) well beyond 2050. Figure 4.2 on the next page illustrates what might happen if, for example, sales of zero-emissions trucks reach 50 per cent by 2040 and 100 per cent by 2050, without any policy to cause diesel trucks to retire early.

Low-emissions drop-in fuel substitutes, such as chemically-indistinguishable diesel made from renewable biomass (Box 3 on page 33), would help reduce truck emissions without requiring early scrapping of existing trucks. The standard should replace existing state-level biodiesel and ethanol targets, because these targets do little to reduce emissions.[95]

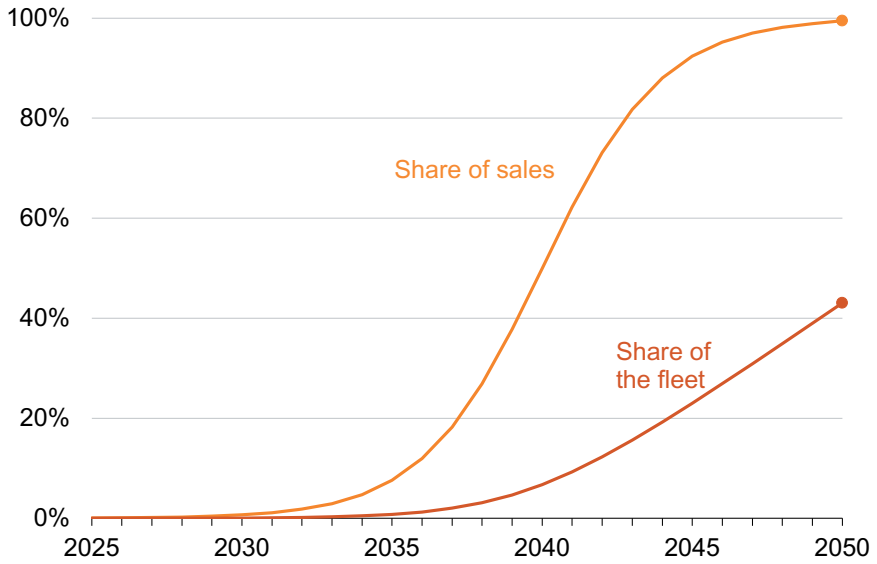
The alternative strategy to reach net zero by 2050 is planning to offset up to 20 million tonnes of truck emissions every year until the fleet is fully decarbonised. This is a risky strategy, given competing demand for offsets from elsewhere in the economy.

If the Federal Government wants to make even faster progress in the heavy vehicle sector, it could consider winding back fuel tax credits, to sharpen the incentive for switching to zero-emissions vehicles. Following hydrogen truck trials, governments could also support installation of hydrogen refuelling stations along major highways where the private sector seemed unlikely to install them.

89. IEA (2020a).
90. *National Transport Commission (Road Transport Legislation – Heavy Vehicle Standards Regulations) Regulations 2006* (Cth), s. 4.4.
91. DITRDC (2021b).
92. By one estimate, the cost to manufacturers is about $30 million a year: DITRDC (ibid).
93. The Federal Government is currently considering whether to widen the limit to 2.55m or 2.6m: DITRDC (ibid, pp. 19–22).
94. Ibid (pp. 19–20).
95. Biodiesel and ethanol are not chemically identical to fossil-fuel diesel and petrol, and therefore can only be used as part of a blend unless engines are modified (Box 3 on page 33). This limits their capacity to fully replace fossil fuels.

Given the uncertainty about which technologies will be most economic for meeting Australia's trucking needs, it is too early to set a phase-out date for the import or registration of petrol/diesel trucks. But governments should review this option within three years.

Figure 4.2: Slow uptake of zero-emissions trucks could mean most of the fleet still uses diesel in 2050
Zero-emissions trucks (electric or fuel cell)



Notes: Adoption curve is stylised, based on a logistic function. It assumes sales of zero-emissions trucks reach 1 per cent by 2030, 50 per cent by 2040, and 100 per cent by 2050. Trucks are assumed to be retired due to age only, at a rate of 4.1 per cent per year (consistent with average vehicle turnover between 2015 and 2020): ABS (2020b).

Source: Grattan analysis.

4.2 Domestic aviation

Emissions from domestic aviation represent 8.4 per cent of transport emissions, and have grown by 58 per cent since 2005.[96] The number of air kilometres travelled domestically has increased by about 60 per cent since 2005, driven by population growth and cheaper airfares (as low as 8c/km).[97] This growth slowed between 2014 and 2019, and emissions dipped sharply during the COVID-19 pandemic. The Federal Government projects a return to growth over 2021 to 2030, with emissions ending up at 10 million tonnes per year by the end of the decade – about 13 per cent higher than they were pre-COVID.

Aviation is a 'hard-to-abate' sector, because there are often no economic alternatives to flying, and a substitute for aviation fuel seems a long way off.[98] Such a fuel needs to be energy-dense (storing a lot of energy in a small volume) and lightweight. R&D and trials continue in second-generation biofuels, partial electrification, and hydrogen, but there is no clear winner at this stage. It may be that the most economic solution is to offset emissions until the zero-emissions technologies mature.

Given the small slice of Australia's emissions that domestic aviation represents, we can afford to wait to make large reductions in emissions in this sector. In the meantime, governments should continue to invest in making hydrogen production and battery technology cheaper and more efficient. And in the spirit of 'small bets', sustainable aviation fuel (SAF) should be included in the renewable fuel-substitutes standard that we recommend in Section 4.4 on the following page.

96. Based on pre-pandemic values for 2019: DISER (2020a).
97. DISER (2021a). Passenger kilometres were 73.5 billion in 2017-18, compared to 45.9 billion in 2004-05: BITRE (2020, p. 81).
98. In Australia, high-speed trains between capital cities do not stack up economically, and they would not help to reduce national emissions before 2050: Terrill et al (2020, p. 12).

4.3 The remaining emissions sources in the transport sector are small

Diesel-powered trains represent just 4 per cent of transport emissions. The solutions here are very similar to those canvassed for heavy vehicles (Section 4.1 on page 29), with hydrogen likely to be the best candidate for long-distance transport. A renewable fuel standard would also help to reduce emissions in this subsector (Section 4.4).

Watercraft represent 2 per cent of transport emissions. The solutions here are likely to vary; ferries could be electrified, as could many pleasurecraft such as jet-skis. But longer distance water transport is likely to require low-emissions fuel. For shipping, the options are likely to be low-emissions drop-in bunker fuel – hence its inclusion in any renewable fuel standard – or switching to hydrogen or ammonia.

Buses produce just 2 per cent of transport emissions; in urban environments, electric buses are already an option. For long-distance coaches, hydrogen may be the longer-term solution.

Motorcycles and scooters produce much less than 1 per cent of the sector's emissions, and electric alternatives are increasingly available.[99]

These modes are generally less-emissions-intensive ways of transporting people or freight than driving, trucking, and flying,[100] and they are overall small sources of emissions. In general, this makes them a lower priority for governments on an emissions basis, except in circumstances where inaction today would lock-in emissions post-2050.

4.4 Renewable fuel standards

Australia should develop its domestic capability to produce drop-in, renewable hydrocarbon substitutes for diesel, aviation fuel, and shipping fuel (Box 3 on the next page). This would provide us with an insurance policy in case zero-emissions technologies emerge too slowly to decarbonise trucking, flying, or shipping by 2050. It would also restore some of Australia's fuel security, given that existing refineries face major economic challenges as the light vehicle fleet moves away from petrol over the next few decades.[101]

The technology exists to make these lower-emissions, drop-in replacement fuels, but the processes are complex and the product is generally not cost-competitive with fossil fuels.[102] The lowest-cost option in the near term is to use waste vegetable oils to make low-emissions diesel or kerosene.[103] As this feed-stock is exhausted, alternative feed-stocks such as municipal waste or agricultural waste could be used instead, though at higher cost due to additional processing.[104] Using waste biomass from the agriculture and forestry industries would also help to create jobs in regional Australia.[105]

Ethanol and biodiesel, which are not simple drop-in replacements, should not be the focus. NSW and Queensland already have blending requirements for these fuels, but they cannot be used in blends beyond about 10-to-20 per cent without engine modification, which makes them poor long-term decarbonisation options.[106]

The Federal Government should introduce a renewable fuel standard that requires retailers and wholesalers to blend some renewable hydrocarbons into their fuels to reduce their emissions intensity. The standard should apply to all sales of diesel, aviation fuel, and shipping fuels. It should be set initially at a modest level – such as 1 per cent

99. Notably, Harley-Davidson has an electric motorcycle, and the company's CEO says 'electrification [of motorcycles] is a given': Rosenbaum (2021).
100. Grattan analysis of BITRE (2020) and DISER (2020a).
101. IEA (2021a, p. 102).
102. IEA (2020b, pp. 157–163); and Le Feuvre (2019).
103. Le Feuvre (2019).
104. Municipal waste is a lower-emissions but not necessarily carbon neutral feed-stock, because some of the waste is itself non-renewable (e.g. plastics).
105. Wood et al (2021, p. 33).
106. NSW Fair Trading (2021); and Business Queensland (2020).

– to commence in 2025, with the option of ramping up to 3.5 per cent or more by 2030, and to higher levels beyond then.[107] Each unit of renewable fuel should generate a certificate that can be sold to other retailers and wholesalers to meet their blending requirement, similar to the functioning of the Large-scale Renewable Energy Target.[108]

Fuel retailers and wholesalers should be allowed to meet the standard across their portfolio of diesel, aviation, and shipping fuel production (but not petrol), rather than having to meet separate standards for each fuel. This would enable feed-stock and production capacity to be used in the most valuable parts of the sector, recognising that fuel demand may fall in some parts of the sector as zero-emissions technology emerges. Excise relief should be introduced on renewable hydrocarbons, to reduce the fuel premium.[109] And, existing state-based mandates for ethanol and biodiesel should be removed or phased out once a national standard is in place, to reduce costs to consumers.

Provenance of feed-stocks for biofuels can raise legitimate environmental and social concerns, here and abroad. Australia should take the lead to develop a low-emissions fuel certification scheme in the Asia-Pacific region, to ensure that low-emissions fuels can be imported or exported with confidence about their integrity. This would mirror the commitment Australia has already made to develop a hydrogen certification scheme as part of its National Hydrogen Strategy.[110] Fuel retailers and wholesalers should be allowed to use imported blended fuels to meet the target, provided they comply with the internationally-recognised certification scheme.[111]

107. The EU target is 3.5 per cent for novel advanced biofuels by 2030: IEA (2020c).
108. This means that some of the fuel sold in Australia would not meet the standard, while other fuel would exceed it, but on average the standard would be met.
109. There is a precedent for this: until 2015, there was a full excise rebate on domestically produced ethanol, and biodiesel produced in or imported into Australia: CEFC and ARENA (2019, p. 7).
110. DISER (2021c).
111. The EU is considering such certification: Goulding Carroll (2021).

Box 3: How can diesel and other fuels be made in a low-emissions way?

Most liquid fuels today are produced from fossil fuels, namely oil. Crude oil contains many combustible chemicals, mainly hydrocarbons, that can be separated and processed in a refinery. Products include petrol, diesel, jet fuel, liquefied petroleum gas, and shipping fuel.

But these hydrocarbon chemicals can also be made from biomass, such as virgin vegetable oils, waste agricultural products, forest residues, animal fat, or used cooking oil. If the biomass is produced in a carbon-neutral way (e.g. without clearing forests or other carbon sinks to grow it), then the liquid fuel product is 'renewable' and has much lower lifecycle emissions than the fossil alternative.[a]

Making fuel in this way tends to be more expensive than refining it from crude oil, with the cost dependent on the feed-stock and the amount of processing required. But the final product is chemically indistinguishable and can be used as a 'drop-in' substitute: no changes need to be made to the engine that uses the fuel. Other biofuels, such as bioethanol and biodiesel, may be renewable, but are not drop-in substitutes.[b] They can be blended into fossil fuels only up to prescribed ratios, before engine modifications are required. In Australia, up to 10 per cent ethanol is often blended into petrol. These fuels can slightly reduce the emissions-intensity of a fuel blend, but they can't be used to effectively decarbonise trucking, freight rail, aviation, or shipping, unless the engines of these vehicles are substantially modified.

a. Hydrogen is generally also an essential input, and this could come from renewable or fossil sources, affecting the overall emissions benefit.
b. Karatzos et al (2014, pp. 14, 25).

5 Implications of the transport transition for other sectors

Decarbonising the transport sector has implications for decarbonising other parts of the economy. These issues will be explored further in the remaining reports in this series, particularly policies for offsets, and the implications for the electricity sector.

Electrification of all road transport – including freight – could add up to 130 terawatt-hours to annual electricity demand – about 50 per cent more demand than there is today.[112] The time of day that electric vehicles are charged could materially affect the shape of the demand load, either for better or worse. If sufficient incentives – such as cost-reflective tariffs – are introduced, there may be widespread uptake of smart technology to coordinate the charging load, and even discharge vehicles at times to supply homes or the grid.

The parts of the transport sector that are most expensive or technologically infeasible to decarbonise – such as aviation, and some of the freight task – are likely to require some offsetting to reach net zero by 2050. That could mean between 10 and 30 million tonnes of offsets per year by 2050. If many petrol/diesel cars remain on the road in 2050, then potentially tens of millions of tonnes of additional offsets will be needed.

The decline in petrol and diesel demand for light vehicles could place significant pressure on refineries, increasing the cost of aviation fuel and diesel for heavy transport and stationary energy. This upward pressure on costs could reduce the green premium from switching to low-carbon alternatives in these subsectors. However, this effect is far from certain because it could be counterbalanced by lower global oil prices.

Future Grattan reports will examine other aspects of transport policy in more detail. Reports from Grattan's Transport and Cities program can be found at www.grattan.edu.au/home/transport-and-cities.

112. Graham and Havas (2020, p. 73); and DISER (2021d).

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