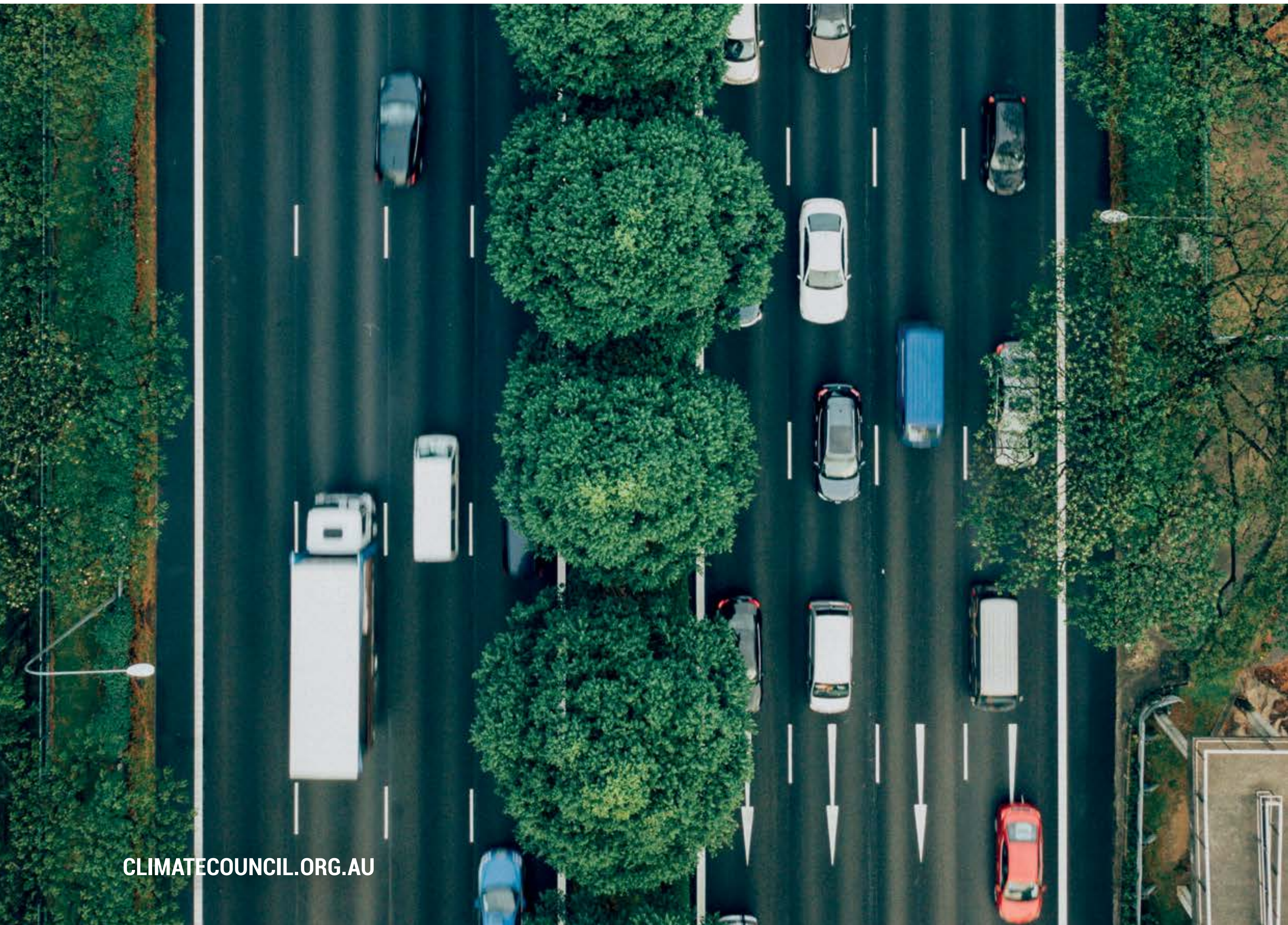
WAITING FOR THE GREEN LIGHT: TRANSPORT SOLUTIONS TO CLIMATE CHANGE



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Preface

This report marks the beginning of a new flagship project for the Climate Council aimed at cutting greenhouse gas pollution levels from the transport sector - Australia's second largest source of greenhouse gas pollution.

Australia's greenhouse gas emissions are rising and are projected to continue increasing in the absence of credible and comprehensive climate and energy policy tackling all key sectors: electricity, transport, stationary energy, agriculture, fugitive emissions, industrial processes, waste and land use.

There has been considerable public discussion in Australia surrounding the need to transition the electricity sector away from polluting, ageing and inefficient coal and gas generation to clean, affordable and reliable renewable power and storage. There are now many policies and programs at the federal, state and local levels designed to drive greater uptake of renewable energy. While more still needs to be done to continue cutting greenhouse gas pollution levels in the electricity sector, there is an urgent need to start addressing pollution from other sectors, particularly transport, the nation's next largest polluter.

Australia's transport emissions or transport greenhouse gas pollution levels have been steadily rising and are projected to continue going up. Factors such as population growth have led to a higher number of cars on the road, while increased demand for freight is also driving up truck emissions. Domestic air travel continues to increase, leading to an increase in aviation emissions (Australian Government 2017).

Solutions are readily available to cut rising greenhouse gas pollution levels from the transport sector. These include introducing vehicle emissions standards, planning for and investing in infrastructure to enable more people to walk, cycle and use public transport, powering cars, buses and rail with renewable energy, along with increasing the uptake of electric vehicles. However, Australia needs federal, state and local policies and investment to set us on the right path to do so.

We would like to thank Dr John Stone, Prof Peter Newman, Dr Graham Sinden (EY), Marion Terrill (Grattan Institute) and Tony Morton (President of the Public Transport Users Association) for kindly reviewing the report.

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Key Findings

1

Transport is Australia's second largest source of greenhouse gas pollution (after electricity).

- Australia's transport related greenhouse gas pollution levels increased 3.4% in the year to December 2017.
- Road based transport accounts for an even greater share of transport pollution in Australia than the global average, at around 85%.
- Cars and light commercial vehicles alone make up over 60% of Australia's transport pollution levels.
- Greenhouse gas pollution levels from transport are projected to continue rising to 2030 and beyond, reaching 112 $MtCO_2e$ in 2030, a further 12% above current levels.

2

Global transport pollution levels are rising by around 2.5% each year. Without action they are expected to double by 2050.

- The transport sector contributes 14% of total global greenhouse gas pollution annually.
- Road related transport - motorcycles, cars, trucks and buses - make up about three quarters of global transport greenhouse gas pollution levels.
- An international scorecard for transport energy efficiency ranked Australia third highest for car distance travelled per capita on an annual basis (8,853 kilometres per person), after the United States (highest, 14,724 kilometres per person) and Canada (second highest, 8,864 kilometres per person). Australia lags behind Russia, Mexico and Indonesia on transport efficiency.

3

Congestion is a $16 billion dollar handbrake on the productivity of Australian cities.

- Congestion in Australia costs the economy more than $16 billion per year - measured in lost private and business time, vehicle costs and air pollution. This figure is expected to rise.
- Demand and congestion on Australian roads will continue to soar as city populations rise. Investing in better public transport infrastructure is a proven means of alleviating congestion.
- Population growth in Australian cities is driving increased demand for public transport. Infrastructure Australia forecasts an 89% increase in demand for public transport between 2011 and 2031.
- Federal and state governments can play a major role in encouraging more people to use public transport through both investing in infrastructure as well as running more frequent public transport services on existing routes.

4

Nearly 8 out of 10 Australians travel to work, school or university by car.

› On average, one in three cars on the road during the morning peak are people making their way to work.

› The majority (79%) of Australian commuters travel to work by car with a much smaller proportion taking public transport (14%), walking (4%) and riding a bicycle (1%).

› The average Australian household spends seven times more on transport (over $11,000 per year) than electricity (around $1,500 per year).

› A study of Sydney transport costs to the taxpayer found cars to be the most expensive mode of travel costing society 86c for every passenger kilometre, compared with rail (the cheapest) at 47c and buses at 57c.

5

Australia is one of just a handful of Organisation for Economic Co-operation and Development (OECD) countries without greenhouse gas emissions standards for vehicles, and lacks credible national policy to tackle transport emissions.

› Mandatory vehicle emissions standards need to be introduced soon to enable Australia to prevent emissions of up to 65 $MtCO_2$ by 2030 (significantly more greenhouse gas pollution than what New South Wales' entire coal fleet produces in a year).

› To tackle climate change, Australia needs to rapidly roll out a fleet of sustainable transport solutions like high quality public transport, cycling and walking infrastructure as well as renewable powered vehicles in the form of electric bicycles, cars, trains, trams and buses.

› By 2025, an electric car is anticipated to be similar in terms of upfront cost compared to a conventional (petrol or diesel) vehicle.

› In Australia, the adoption of electric vehicles is being held back by the lack of policy support or incentives, higher upfront cost, lack of choice of available electric vehicles for sale in Australia, and the availability of public vehicle charging infrastructure.

Recommendations for policy makers

1

Federal, State and Territory governments to set targets for zero emissions, fossil fuel free transport well before 2050. Develop a climate and transport policy and implementation plan to achieve these targets.

2

Ensure cost benefit analyses for all transport project business cases account for the additional greenhouse gas pollution that projects will lock in over their lifetime, or pollution avoided (e.g. from public transport improvements).

3

Establish mode shift targets for public transport, cycling and walking.

4

Ensure that at least 50% of all Federal, State and Territory Government transport infrastructure spending is directed to public and active (e.g. walking and cycling) transport.

5

Federal, State and Territory governments to introduce targets to drive uptake of electric buses, trucks, cars and bicycles powered by renewables. Electric vehicle targets can be established for specific sectors and government operations, including:

- State and territory public transport systems.
- Federal, state and territory government vehicle fleet purchases.

6

State and Territory Governments to contract additional 100% renewable energy to power public transport systems (trains, light rail and buses).

7

Federal Government to introduce strong vehicle greenhouse gas emissions standards. State and Territory Governments to advocate for vehicle emissions standards through the Council of Australian Government's Transport and Infrastructure Council.

8

Federal, State and Territory governments to encourage the rollout of 100% renewable powered electric vehicle charging, particularly in regional areas and interstate routes.

9

Put a price on pollution. Consider policies or pricing which better reflects the cost of greenhouse gas pollution, so that road or public transport users bear the cost, or reap economic benefits based on emissions associated with their chosen travel mode. End government subsidies, incentives and support for fossil fuel use in the transport sector.

Contents

1. Introduction

Road and public transport systems in Australia are under increasing strain due to growing populations, the layout of our cities and suburbs, our heavy reliance on cars to get around, and in many cases the lack of suitable public transport alternatives. As the transport systems in our major cities come under pressure, some commuters and communities are experiencing negative effects such as high transport costs and travel times, congestion, overcrowding, noise, air pollution, and reduced physical activity.

Crucially, our transport systems are failing when it comes to tackling climate change. Transport is now Australia's second largest source of greenhouse gas pollution (after electricity) and the sector has seen the largest percentage growth (62.9%) since 1990 (Department of Environment and Energy 2018a). Without action, transport emissions will continue rising (Department of Environment and Energy 2017).

Australia can do much more to reduce greenhouse gas pollution from the transport sector. Compared with other countries, Australia consistently ranks at the back of the pack when it comes to tackling its transport emissions (ACEEE 2018). In fact, Australia's cars are more polluting; our relative investment in and use of public and active transport options is lower than comparable countries; and we lack credible targets, policies, or plans to reduce greenhouse gas pollution from transport.

Action on climate change is urgent. The world experienced its hottest five-year period on record between 2013 and 2017, continuing a strong, long-term upswing in global temperatures (Climate Council 2018; NOAA 2018). Increasing global heat, driven primarily by the burning of fossil fuels like coal, oil and gas, is exacerbating extreme weather events around the globe and in Australia.

Australia is failing to tackle greenhouse gas pollution from transport; our second highest emitter.

Greenhouse gas pollution from air travel is also significant and rising.

Transport systems are vulnerable to disruptions and damage from more frequent and intense extreme weather events such as heatwaves, storms and bushfires. For example, on 7 January 2018, the Sydney suburb of Penrith was recorded as the hottest place on earth over a 24-hour period (with temperatures reaching 47.3°C). This extreme heat led to cancellations and delays across the city's public transport system (News.com.au 2018; SMH 2018a).

Transport plans, policies and investments made today have long-term implications decades into the future. These impacts include concerns over how efficiently we will be able to move around our major cities, how rapidly we can cut greenhouse gas pollution, and how well our transport systems are able to withstand the impacts of extreme weather.

To tackle climate change, Australia must rapidly roll out a fleet of sustainable transport solutions. These include improving the quality, efficiency and accessibility of public transport, cycling and walking alternatives as well as shifting to renewable powered vehicles in the form of electric bicycles, cars, trains, trams and buses. Australian governments need to develop coherent transport and climate change policies with the aim of lowering greenhouse gas pollution across the sector.

Transport policies need to consider the many factors that influence people's transport choices - family, work and household circumstances, housing choices, comparative costs, how long it takes to get from A to B and whether the route is direct or meandering. Fortunately, there are many transport solutions available that can both drive down greenhouse gas pollution levels, while also bringing significant environmental, health and economic benefits.

This report focuses on climate solutions to road-based transport, as cars, commercial vehicles, trucks and buses make up the vast majority (85%) of Australia's transport-related greenhouse gas emissions. It is important to note emissions from domestic and international air travel are also significant and rising, with domestic air travel alone making up 9% of Australia's transport emissions.

Section two of this report provides an overview of the transport sector's contribution to greenhouse gas pollution globally and in Australia. Section three considers how Australia's transport sector emissions measure up compared with other nations. Section four provides background to some of the pressures facing Australian cities and their transport systems. Section five describes key climate solutions to drive down transport emissions in Australia. Section six highlights a range of local and international case studies of transport climate solutions.

2. Transport and climate change

Greenhouse gas pollution from transport represents a significant share of emissions both globally and in Australia, with pollution increasing year on year.

Globally, the transport sector contributes nearly a quarter of energy-related carbon dioxide pollution. The transport sector contributes 14% of total global greenhouse gas pollution annually (7.0 $GtCO_2$ in 2010) (IPCC 2014). Road related transport - motorcycles, cars, trucks and buses - make up about three quarters of global transport emissions (The ICCT 2017).

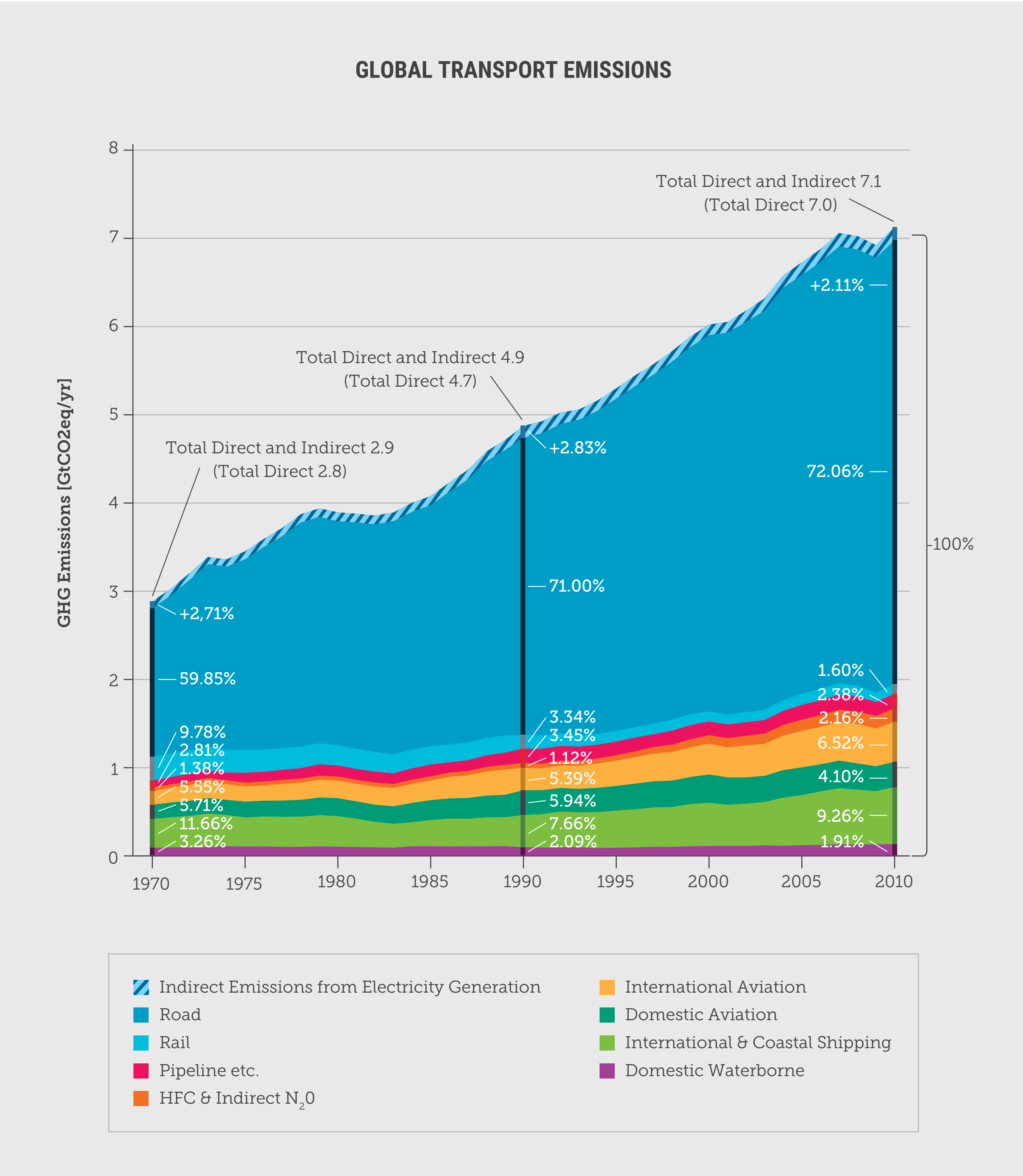
Transport emissions are rising (Figure 1). Worldwide transport-related emissions are increasing by around 2.5% every year (IEA 2017b; The ICCT 2017). Without action, transport emissions are expected to double by 2050 (IPCC 2014; Figure 1).

In Australia, transport (18%, 100 $MtCO_2e$) is the second largest source of greenhouse gas pollution after electricity (33%, 184.5 $MtCO_2e$). Australia's transport related emissions increased 3.4% in the year to December 2017 (Department of the Environment and Energy 2018a).

Road based transport accounts for an even greater share of transport emissions in Australia than the global average, at around 85% (Department of the Environment and Energy 2017). Cars and light commercial vehicles alone make up over 60% of Australia's transport emissions. New South Wales has the highest total transport emissions of any state or territory, whereas Western Australia has the highest transport emissions on a per capita basis.

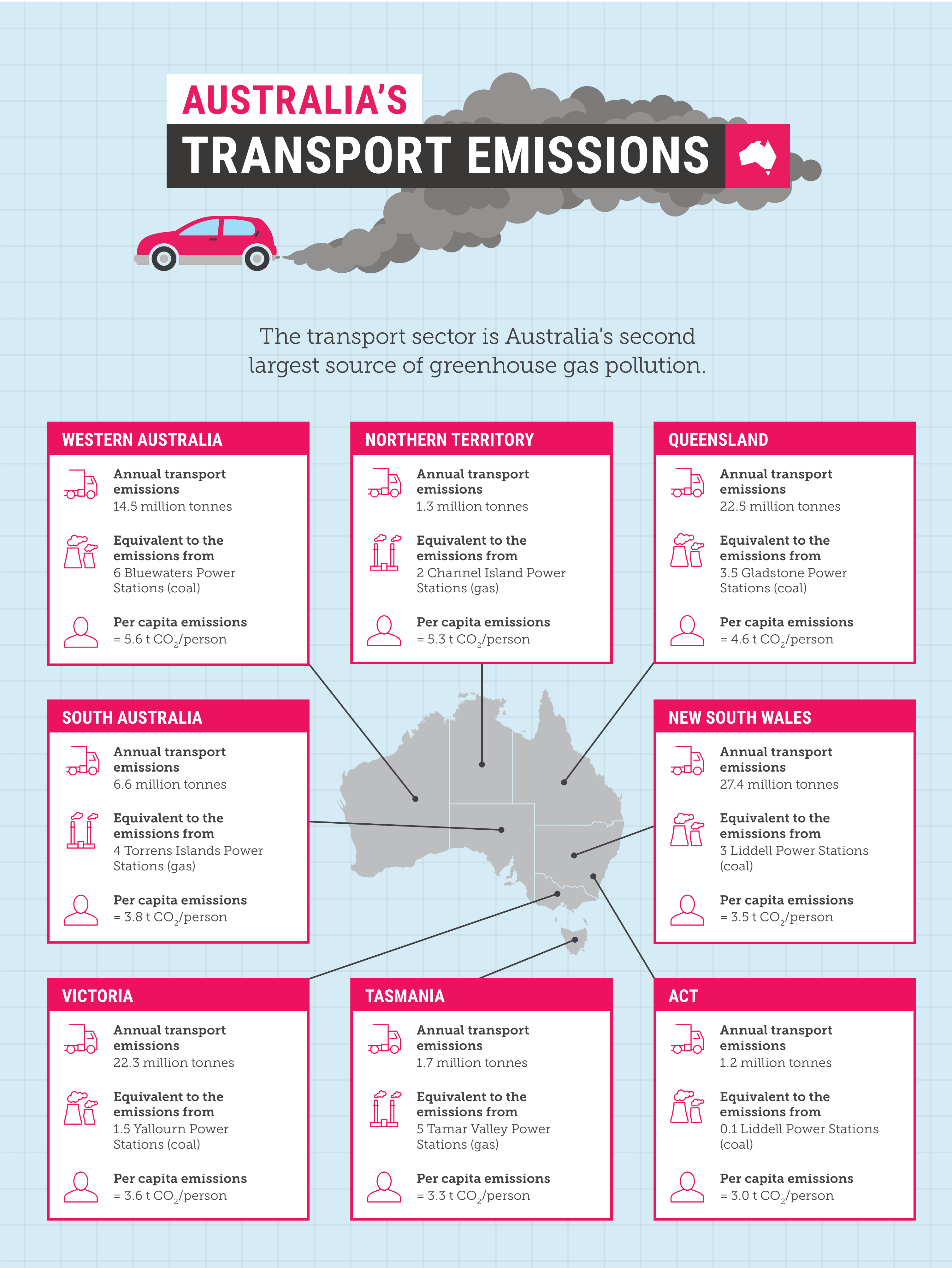
Australia's transport sector adds 100 million tonnes of greenhouse gas pollution to the atmosphere every year.

Figure 1: Global transport emissions are rapidly rising.



Source: IPCC 2014.

Figure 2: State and territory transport emissions.

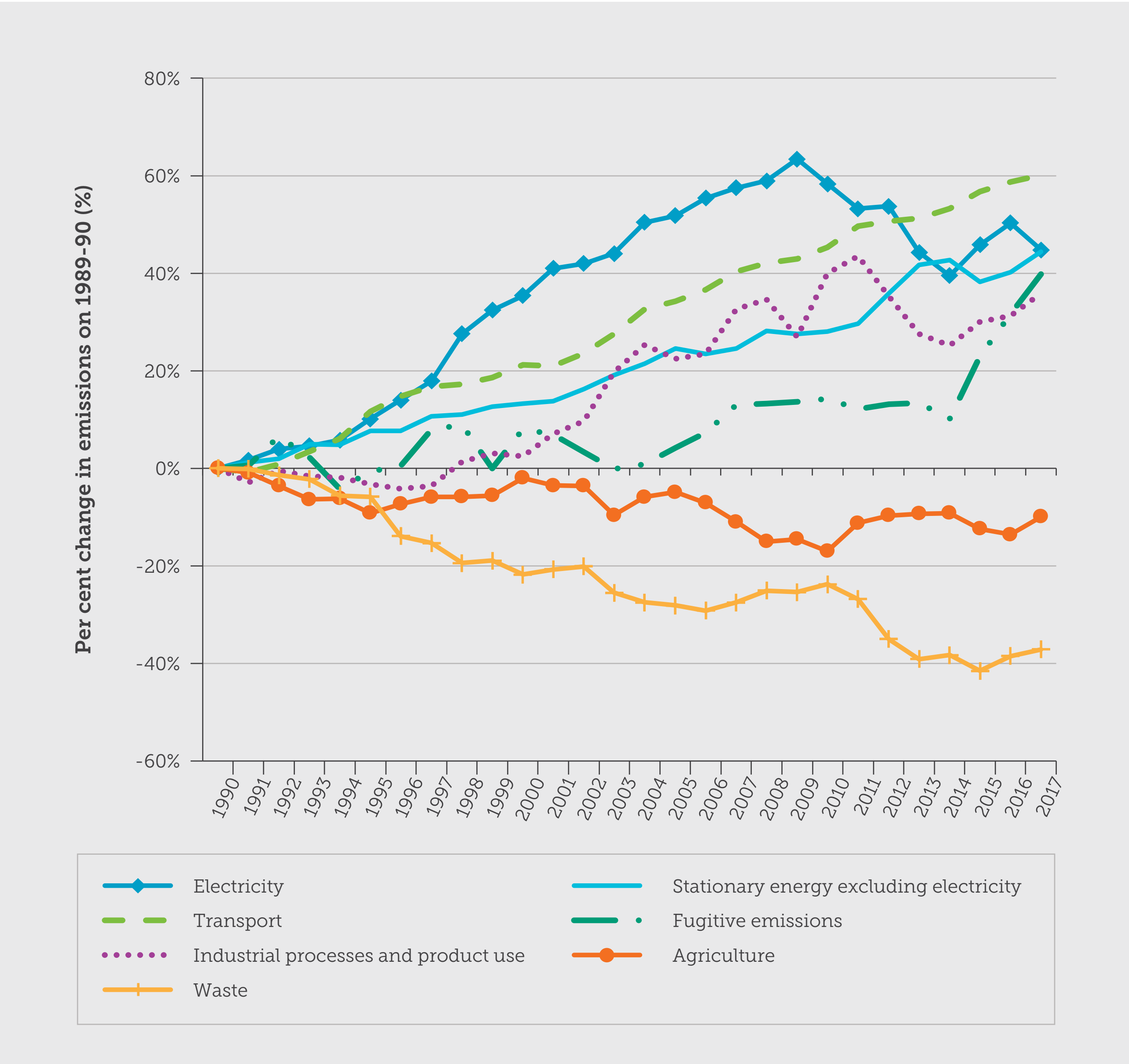


Sources: ABS 2017a; Clean Energy Regulator 2018; Department of the Environment and Energy 2018b.

Greenhouse gas pollution from cars, trucks and buses is on the rise both globally and in Australia.

In Australia, greenhouse gas emissions from transport have increased dramatically since 1990 (62.9%), experiencing higher growth than any other sector. Pollution levels from transport are projected to continue rising to 2030 and beyond, reaching 112 $MtCO_2e$ in 2030, a further 12% above current levels (Department of the Environment and Energy 2017; Figure 3).

Figure 3: Transport emissions increased the most as a percentage of any sector since 1990.



Source: Department of the Environment and Energy 2018a.

Emissions from the transport sector must be rapidly reduced in order to tackle climate change (IEA 2017b).

Transport solutions - improving city planning; investing in public transport; encouraging people to shift out of cars and on to public and active transport modes; and adopting technological developments such as renewable powered electric cars, buses, light rail and trains - are together capable of reducing greenhouse gas pollution levels globally by 15 - 40% from business as usual by 2050 (IPCC 2014).

BOX 1: THE CLIMATE BENEFITS OF CANBERRA'S LIGHT RAIL PROJECT

Commencing construction in 2016, the Australian Capital Territory's Capital Metro Light Rail (CMLR) system will be a transformative project for the Canberra-Queanbeyan urban area, bringing a wide range of economic, health, social and environmental benefits. Climate benefits are an important component of that list.

The first stage of the CMLR system – a 12 kilometre line from the northern town centre of Gungahlin to Canberra's city centre – will be fully operational in 2019. It will achieve a reduction in greenhouse gas emissions along the transit corridor of up to 30% compared to the business-as-usual case with no light rail, based on the number of passengers who shift from private cars to light rail.

Even more impressive are the reductions on a per-passenger basis. For every passenger who switches from a car to the light rail, emissions will be reduced by 100%, that is, a complete decarbonisation of the trip.

The reason for this massive reduction in per-passenger emissions is two-fold. First, moving from a car to the light rail system reduces emissions to only a sixth of what it would have been had the passenger stayed in the car. Second, the CMLR trains will be powered by electricity, not by liquid fuels such as petrol that directly emit CO_2 on combustion.

By 2020 the ACT has contracted enough wind and solar power to ensure the Territory is powered by 100% renewable electricity. So the electricity powering the trains will be entirely free of greenhouse gas emissions.

The other way that the CMLR system will reduce greenhouse gas pollution is by the land use change it will enhance. As people will want to live and work near the fast, high quality rail service, land development will be attracted closer in to the city rather than in highly car dependent suburbs on the urban fringe. Such changes in land use not only make the economics of urban rail much more attractive, they also reduce greenhouse gas pollution on the train and on all the travel done by those living closer to the city.

These very large emission reductions show the potential of quality public transport such as light rail, running on renewable energy, to drastically reduce greenhouse gas emissions on a per passenger basis and cut greenhouse gas pollution for the transport sector. In the longer term, the light rail network will become the backbone of a transformed transit system – integrated with bus routes, cycleways, walking corridors and electric vehicle charging stations – delivering an efficient, resilient, carbon-free transit system, powered by renewable energy.

Source: Steffen et al 2015.

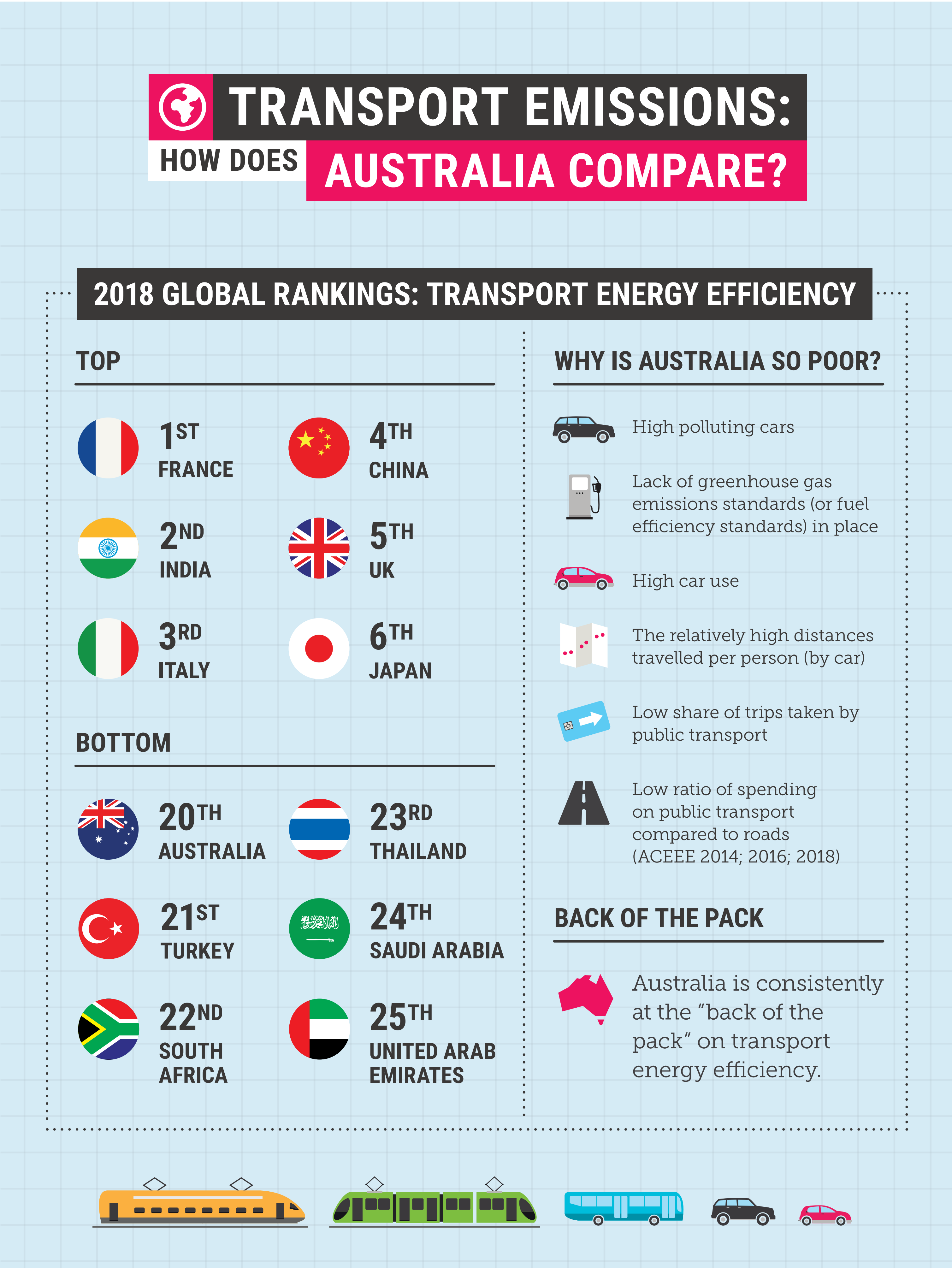
3. Transport emissions: How does Australia compare?

An international scorecard comparing the energy efficiency of the world's top energy consuming countries consistently places Australia at the "back of the pack" on transport energy efficiency due to:

- High polluting cars
- Lack of greenhouse gas emissions standards (or fuel efficiency standards) in place
- High car use
- The relatively high distances travelled per person (by car)
- Low share of trips taken by public transport
- Low ratio of capital spending on public transport compared to roads (ACEEE 2014; 2016; 2018)

Australia lags behind Russia, Mexico and Indonesia on transport efficiency.

Figure 4: 2018 International Energy Efficiency Score Card - Transport.

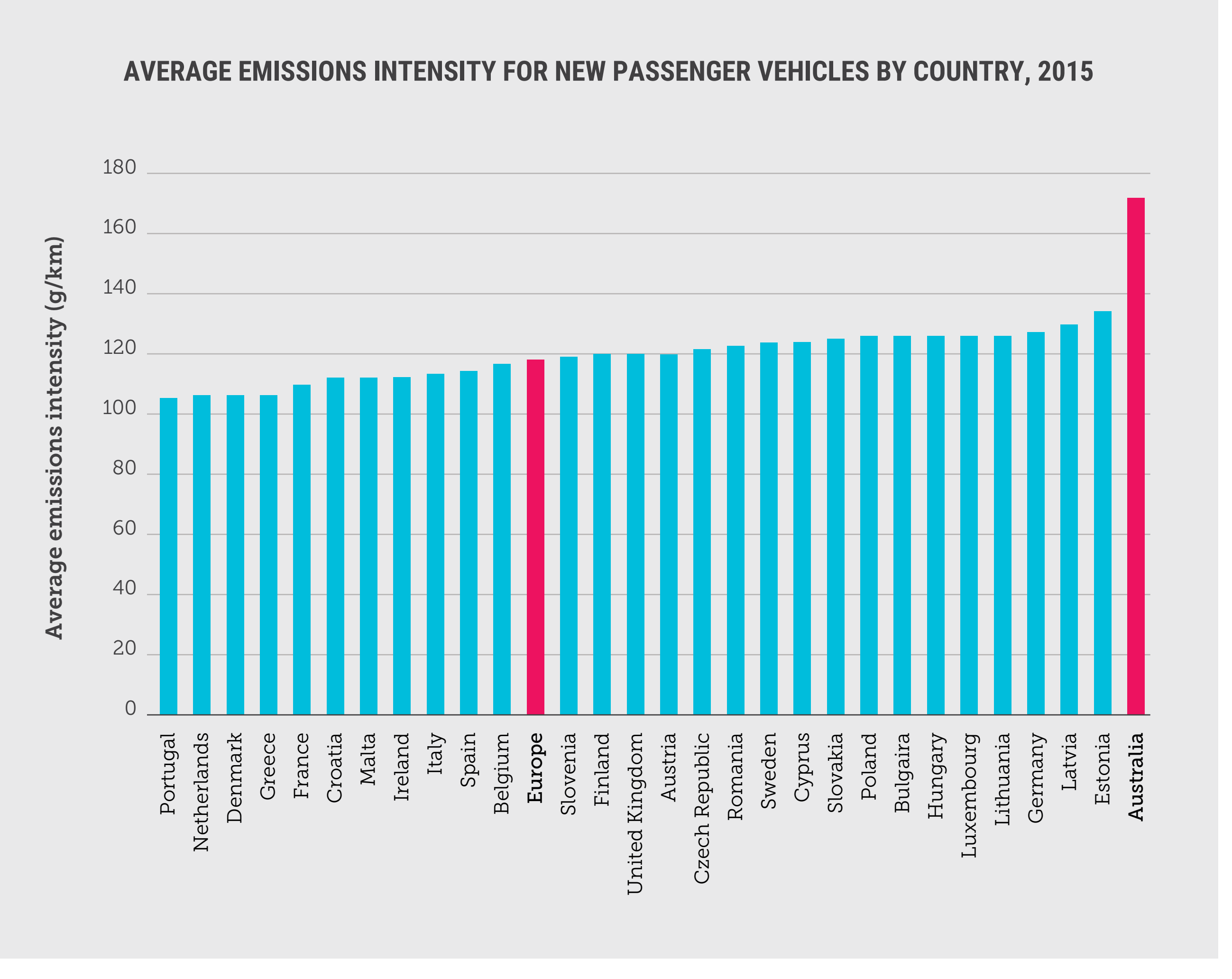


Sources: ACEEE 2018.

3.1 Australian cars pollute more

Australian vehicles emit more greenhouse gas pollution per kilometre than comparable countries. The average car purchased in Australia emits 182g of carbon dioxide per kilometre (g/km) (NTC 2017). This is much higher than comparable countries. For example, the emissions intensity of Australian vehicles is 46% higher than vehicles in European countries (NTC 2017; Figure 5).

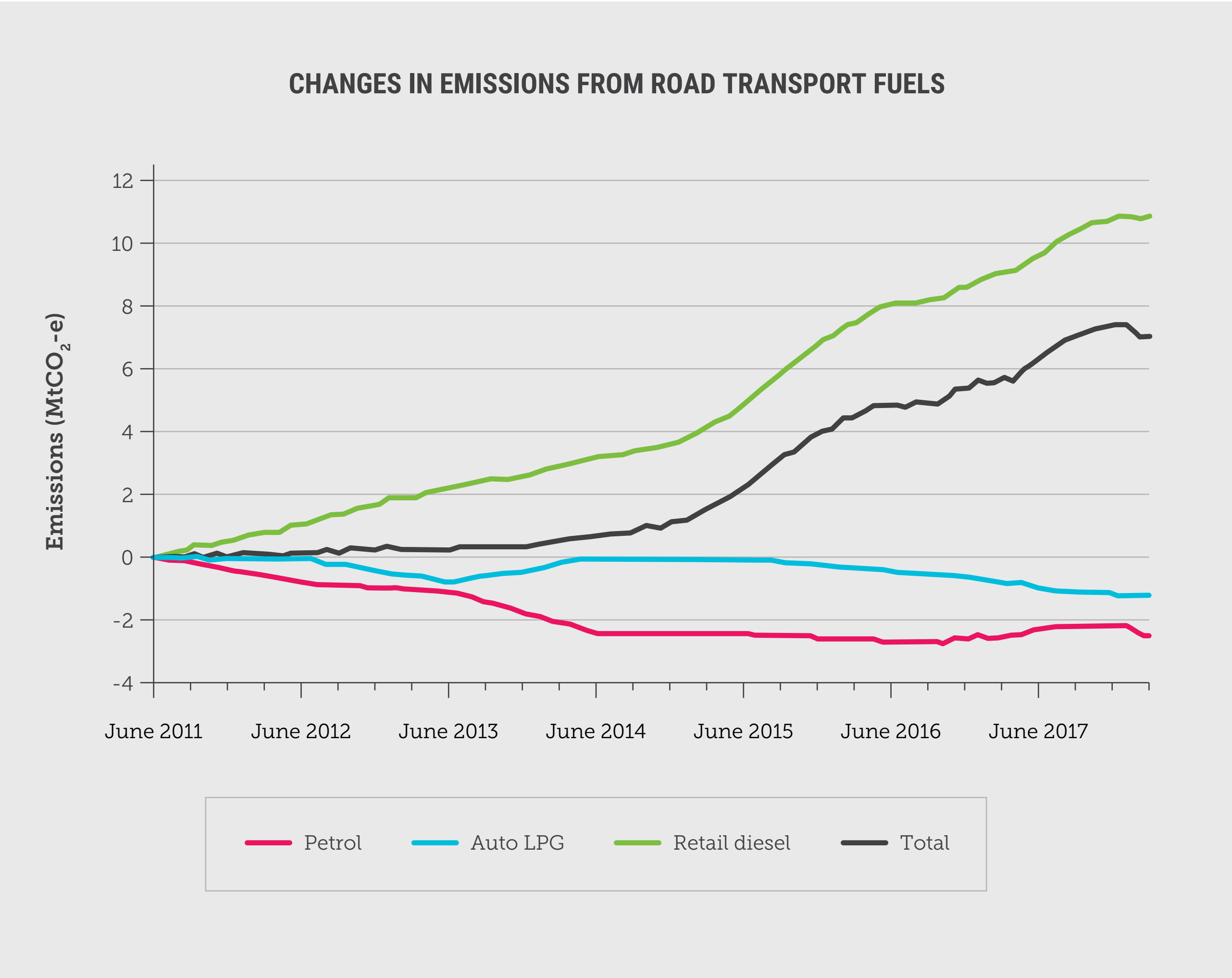
Figure 5: Emissions intensity for new passenger vehicles - Australia compared with European countries.



Source: NTC 2017.

Australian cars pollute more per kilometre than other comparable countries due to a range of factors, including vehicle size, the lack of mandatory greenhouse gas emissions standards for cars, as well as purchasing decisions made by individuals, business and government fleet buyers (NTC 2017). Since 2011, diesel emissions have gone up significantly as more people choose diesel vehicles (TAI 2018; Figure 6).

Figure 6: Diesel emissions have risen as more people choose diesel cars.



Source: TAI 2018.

3.2 Australians depend heavily on cars to get around

Australians rely heavily on their cars to get around, particularly when travelling to work, school or university. A greater proportion of people drive in Australian cities (rather than using public transport) compared to overseas (ACOLA 2015). For example, the majority (79%) of Australian commuters travel to work by car with a much smaller proportion taking public transport (14%), walking (4%) or riding a bicycle (1%) (BITRE 2017).

An international scorecard for transport energy efficiency ranked Australia third highest for car distance travelled per capita on an annual basis (8,853 kilometres per person), after the United States (highest, 14,724 kilometres per person) and Canada (second highest, 8,864 kilometres per person) compared with 25 high energy consuming nations (ACEEE 2018).

Sydney, Melbourne and Brisbane are Australia's most populous cities and have higher car ownership than other global cities (UITP 2015). Global research comparing transport trends in more than 60 cities worldwide found Australian cities (Brisbane, Melbourne and Sydney) were amongst the top third of cities in terms of car ownership per capita. Of the cities compared, Brisbane had the fourth highest car ownership per capita overall after Portland (US), Turin and Rome (Italy) (UITP 2015).

There are some signs of a cultural shift away from private car ownership. Younger Australians (born after 1982) are less likely to obtain a drivers license, less likely to own their own vehicle and more likely to prefer walking and public transport. Technological developments such as autonomous vehicles, electric vehicles, car sharing and ride sharing are expected to change car ownership patterns, but not necessarily reduce car use (NRMA 2017).

Nearly 8 out of 10 Australians travel to work, school or university by car.

3.3 Low use and limited access to public transport in Australian cities

Australia's most populous cities - Sydney, Melbourne and Brisbane - have lower supply of and use of public transport compared with other global cities (UITP 2015).

A study of 39 countries placed Australia among the lowest for levels of public transport use in terms of journeys per capita (UITP 2017).

Research comparing transport trends in more than 60 cities worldwide found Australian cities (Brisbane, Melbourne and Sydney) were among the lowest 25% based on supply of public transport (measured in total public transport vehicle kilometres per capita) and demand for public transport (measured in passenger kilometres per capita) (UITP 2015). However, demand for public transport is growing in Australia, linked to inner city population growth and investment in new lines and services (UITP 2017).

Solutions to reduce Australia's greenhouse gas pollution from the transport sector are outlined in Section 4.

Table 1: Public transport use.

Higher use (More than 10% larger than average)	**Medium use** (Within 10% of average)	**Lower use** (More than 10% smaller use than average)
Singapore, Czech Republic, Hungary, Austria, Luxembourg, Japan, Republic of Korea, Estonia, Switzerland, Lithuania, Germany, Sweden, Poland, Latvia, Romania, Croatia, Ukraine, France, Slovakia, UK, Norway	Italy, Turkey, Belgium, Bulgaria, Russia, Finland, Brazil, China	Denmark, Portugal, Canada, Spain, Malta, Australia, Ireland, Slovenia, US, New Zealand

Source: UITP 2017.

4. Pressures on and impacts from transport in Australian cities

Population growth in Australian cities is placing increased pressure on both road and public transport networks, leading to issues such as overcrowding and congestion. The approach to transport in our cities has a number of social, economic and environmental implications.

Population growth in Australian cities is putting pressure on transport networks.

4.1 Population growth placing pressure on transport systems

Australia's major cities are facing record levels of demand on road and public transport systems as urban populations surge (Commonwealth of Australia 2016a). Melbourne and Sydney both added more than 100,000 people over the past year, Brisbane added around 48,000 people and Perth an additional 21,000 (ABS 2018a; Table 2).

Table 2: Population growth in Australian capital cities.

Capital city	Population 2017	Population change 2016 - 2017	Growth 2016 - 2017
Melbourne	4,850,740	125,424	2.7%
Sydney	5,131,326	101,558	2.0%
Brisbane	2,408,223	47,982	2.0%
Canberra	410,301	6,833	1.7%
Hobart	226,884	2,422	1.1%
Perth	2,043,138	21,094	1.0%
Adelaide	1,333,927	9,648	0.7%
Darwin	146,612	696	0.5%

Source: ABS 2018a.

4.2 Congested roads

Many Australian roads are congested at peak times. The average car trip to the city in Sydney or Melbourne takes 50-70% longer during the morning peak than it would at night (Terrill M 2017). Travel times in all four big Australian cities have grown beyond the 30-minute average travel time, a period considered to be an acceptable journey time from home to work (Newman and Kenworthy 2015; Figure 7).

On average, one in three cars on the road during the morning peak are people making their way to work. Approximately one in five are travelling to school or university (BITRE 2016a). More than 60% of children are now driven to and from school (ACOLA 2015), with some parents reportedly travelling up to 100 kilometres to drive children to their school of choice (SMH 2018a; The Age 2018a).

Figure 7: Average commuting times for full time workers in Sydney, Melbourne, Brisbane and Perth.

Source: BITRE 2016b.

Congestion represents a cost to the economy and a handbrake on the productivity of our cities. In Australia, the annual economic cost of congestion - measured in lost private and business time, vehicle costs and air pollution - is estimated at over $16 billion per year and is expected to rise (BITRE 2016b). While congestion represents a cost to the economy, it is important to note that reducing congestion is not without cost, often requiring new investment in public transport or funds for administering road pricing policies (Terrill 2017). Eliminating congestion entirely from major city roads is an unrealistic goal, given a certain amount of congestion reflects an efficient use of road space (Whitehead 2015).

Reducing congestion requires investing in public and active transport alternatives together with congestion charges or disincentives discouraging people from driving at peak times (Aftabuzzaman et al 2010; Glover 2013; Whitehead 2015). On the other hand, building more roads often contributes to increased traffic, as more people decide to drive, in turn increasing road congestion (Glover 2013; Beck and Bliemer 2015; Whitehead 2015).

New roads are often sold to the public as "congestion busters"; however, research consistently shows that increasing road capacity can actually increase congestion by encouraging additional car trips as traffic increases to fill the available road space (Litman 2015). While counter-intuitive, removing roads may over-time result in improved traffic conditions (Beck and Bliemer 2015).

Congestion is a $16 billion dollar handbrake on the productivity of Australian cities.

Where public transport provides an alternative service to driving that is efficient, affordable, and meets people's travel needs, this can lead to more and more people using public transport and less tolerance for driving and road congestion, ultimately creating a lasting improvement in road traffic conditions. Importantly though, this will only happen if planners resist the temptation to undermine the mode shift to public transport (and away from private cars) by adding more road capacity.

For example, Beijing has successfully reduced congestion by 50% year-on-year from 2010 by prioritizing public transport in planning and investment, expanding the rail network by three new subway lines (totalling 36 kilometres of rail) and limiting increases in car ownership. Public transport now accounts for over 40% of all trips, and peak hour travel speeds have improved by more than 10% (International Transport Forum 2013).

4.3 Increasing demand for public transport systems

Most Australian capital cities offer a range of public transport services: rail (in the form of trains and light rail), buses and in some cases ferries. In 2016, public transport users in Sydney, Melbourne (e.g. Figure 8), Brisbane, Adelaide and Perth took 680 million trips by rail (trains) and 230 million trips on light rail (BITRE 2017).

Population growth in Australian cities is driving increased demand for public transport. Infrastructure Australia forecasts an 89% increase in demand for public transport between 2011 and 2031 (Infrastructure Australia 2016).

The capacity of public transport to move more people in Australian cities and towns depends on diverse factors including infrastructure, technology measures (e.g. signalling), fleet size, staffing, and even the design of stations and interchanges.

Light rail and urban trains generally tend to service inner city suburbs, or extend like spokes of a wheel, connecting the central city to outer suburbs. Trams (street-based light rail) generally operate up to around 10 kilometres from the central city (Victorian Auditor General 2014), whereas light rail can extend further into suburbs and hinterlands. In recent years most Australian cities have been building fast

Figure 8: Melbourne's Flinders Street Station.

rail into the outer suburbs to ease the travel times of people living a long way from work and these have been highly successful in drawing people out of cars (Glazebrook and Newman 2018). The Western Australian Government's MetroNet program has major rail connections into five corridors of Perth costing over $5 billion. Other significant rail investments include Adelaide's rail extension to Noarlunga, Sydney's North West and South West rail projects, Melbourne's new South West line and Melbourne Metro, the Canberra and Gold Coast Light Rail projects and Sunshine Coast rail projects. Pressure on existing transport systems and communities experiencing long travel times to work and other major services have been strong drivers for these rail investments. The change in priorities from spending on roads and buses to building fast rail services has happened mostly over this century and is paralleled by changes across the world (Newman, Glazebrook and Kenworthy 2012; Glazebrook and Newman 2018).

The trend to build urban rail in recent decades across the globe has been documented by Newman and Kenworthy (2015) who show that urban or metro rail is now faster than traffic in most cities (including Australia) as traffic has slowed from congestion and new fast rail systems are being built that go over, around or under the traffic. Table 3 shows this trend and the opportunity through rail to enable large shifts in modal split away from cars.

Buses have provided the backbone of public transport in Australian cities, particularly for those living in the outer suburbs, for the past 50 years. A study of Melbourne public transport found nearly 90% of homes are located within walking distance (400 metres) to one or more modes of public transport - over 80% lived near a local bus, around 30% near a train, and 20% near a tram (Victorian Auditor General 2014).

Figure 9: Canberra Bus.

Table 3: Ratio of overall average transit system and rail speed to general road traffic speed in cities, 1960 to 2005.

Comparative speeds in global ciites	1960	1970	1980	1990	1995	2005
Ratio of overall public transport system						
American Cities	0.46	0.48	0.55	0.50	0.55	0.54
Canadian Cities	0.54	0.54	0.52	0.58	0.56	0.55
Australian Cities	0.56	0.56	0.63	0.64	0.75	0.75
European Cities	0.72	0.70	0.82	0.91	0.81	0.90
Asian Cities	-	0.77	0.84	0.79	0.86	0.86
Global average for all cities	**0.55**	**0.58**	**0.66**	**0.66**	**0.71**	**0.70**
Ratio of metro/suburban rail speed to road speed						
American Cities	-	0.93	0.99	0.89	0.96	0.95
Canadian Cities	-	-	0.73	0.92	0.85	0.89
Australian Cities	0.72	0.68	0.89	0.81	1.06	1.08
European Cities	1.07	0.80	1.22	1.25	1.15	1.28
Asian Cities	-	1.40	1.53	1.60	1.54	1.52
Global average for all cities	**0.88**	**1.05**	**1.07**	**1.11**	**1.12**	**1.13**

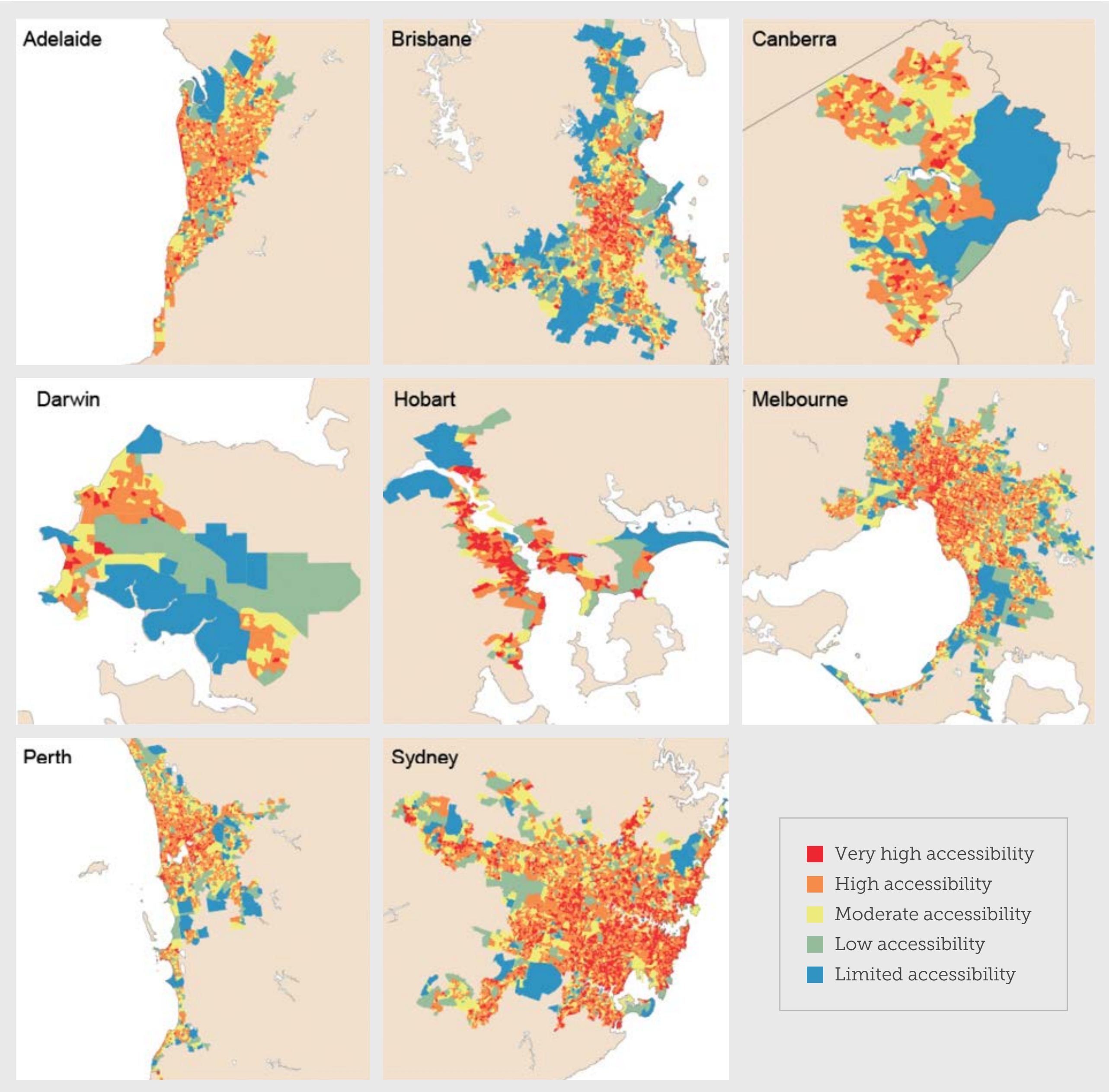
Source: Newman and Kenworthy (2015).

Accessibility of public transport services is critical.

Accessibility of public transport is critical to encouraging more people to take the bus, light rail or train instead of driving. Hobart and Sydney ranked the highest in terms of the percentage of residents with high or very high accessibility (of nearby public transport stops). However, this does not matter if the speed and quality of the public transport option is not better than that provided by cars[1]. Out of the capital cities, Brisbane had the largest proportion of residents having low or limited access to public transport (Commonwealth of Australia 2016b; Figure 10).

1 Accessibility is defined geographically and does not take into account the quality or how frequent the service is.

Figure 10: Accessibility of public transport in Australian cities.



Source: Commonwealth of Australia 2016b.

Light rail and trains in Australian cities are bursting at the seams.

Many public transport systems in our major cities, particularly light rail and train services, are bursting at the seams. Many public transport services are already at or beyond capacity during peak periods, leading to crowding, delays and worsening quality of service. Ongoing rapid growth and investment in new high quality public transport systems is needed to tackle climate change and make our cities responsive and resilient.

In contrast, many bus services are characterised by low use and low levels of satisfaction. Issues affecting bus services and levels of use include indirect routes, infrequent services, limited hours of operation and poor coordination with trains and light rail (Victorian Auditor General 2014).

Buses can be very slow in the transport system. In recent decades our streets have become more congested and unfortunately buses are also stuck in the traffic. This drawback for efficient bus systems has partly contributed to the preference in Australian cities for a faster rail connection to the outer suburbs.

In general, the service level of buses and light rail in our major cities (like Sydney and Melbourne) are poor compared to other global cities in terms of provision, frequency, average speeds and unplanned disruptions. Investment in and increases in public transport service have not kept pace with population growth (Currie 2016).

Rapid growth and investment in public transport systems is needed to tackle climate change.

4.4 Health and wellbeing impacts from transport choices

People living in Australian cities are spending a large proportion of time travelling to and from work, school or university. Those living in Sydney (5:42 hours per week), and Brisbane (5:00 hours) are spending a large amount of time each week in the car, train, light rail, tram or bus (AMP 2011, e.g. Figure 11). However those living in the Northern Territory are spending less than three hours a week commuting to work.

Time spent commuting impacts on people's work and leisure time. Long commutes also negatively affect people's wellbeing, stress levels, and their relationships with families, communities and workplaces (TAI 2005).

The way people travel - by car or public transport - can have ramifications for their health. Public transport use is linked to lower weight and higher levels of physical activity compared to driving. This is due to incidental physical activity such as walking to or from the train station or bus stops (Rissel et al 2012). Compared with driving, public transport users:

› are 3.5 times more likely to meet recommended levels of physical activity (30 minutes a day)

› walk an extra 8 to 33 additional minutes each day

› are less likely to be sedentary or obese (Rissel et al 2012).

People living in Australia's major cities are spending between four and six hours a week in the car, train, light rail, tram or bus.

Public transport users are more likely to meet recommended levels of exercise.

A study of incidental physical activity associated with public transport use in Melbourne found car drivers average 10 minutes of daily physical activity, whereas public transport users achieve 35 minutes, and walkers and cyclists 38 minutes (Beavis and Moodie 2014).

One of the healthiest forms of travel is walking. The rebuilding of cities to make them more walkable has been the life work of Danish urban designer Jan Gehl (Matan and Newman 2016). Gehl's work in Melbourne, Sydney, Adelaide and Perth has been critical to their becoming far more walkable in their central cities, regenerating the original walking urban fabric (Newman et al 2016). This has been the basis of strong economic performance, higher liveability, greater health and reduced car use. Such activities have demonstrated the importance of co-benefits in achieving reductions in transport greenhouse gas pollution.

Figure 11: Traffic congestion in Sydney.

4.5 Urban air pollution and noise

In Australia, an estimated 1,700 deaths occur every year as a result air pollution from cars, trucks and buses - larger than the national road toll (Schofield et al 2017; Department of Infrastructure, Regional Development and Cities 2018).

Diesel cars, trucks and buses are key sources of urban air pollution. Diesel is becoming an increasing source of air pollution in Australian cities (Commonwealth of Australia 2016a). Diesel-fuelled vehicles emit air pollutants such as nitrogen oxides and particulate matter, which can cause cancer and respiratory problems (Nieuwenhuis 2017).

The use of diesel is increasing across Australia both for road transport and other activities (agriculture, mining, construction) (TAI 2018). Sales of diesel cars are growing in Australia, increasing 8.5% between 2015 and 2016 (NTC 2017). Bus routes in Australia are predominantly serviced by diesel buses. Out of 97,000 buses on Australian roads, four out of every five are diesel (ABS 2017c).

Across the world many cities are banning diesel for health reasons and because electric vehicle alternatives of all kinds are now the rapidly growing new market. Electric vehicles can reduce urban air pollution and noise.

Simple measures such as discouraging the practice of idling (when a vehicle's engine is left running unnecessarily) near schools and childcare centres can reduce children's exposure to noxious chemicals as well as reducing greenhouse gas pollution (Schofield et al 2017; The Age 2017).

Diesel buses, trucks and cars are a key source of air pollution.

4.6 The cost of transport

Despite the recent focus on energy bills, the average Australian household spends seven times more on transport (over $11,000 per year) than electricity (around $1,500 per year) (ABS 2017b; ACCC 2017).

Compared to driving, public transport is cheaper for individuals, households, and society, particularly when all external costs are factored in (for example, public expenditure, accidents, congestion, air pollution, and noise costs).

At a household or individual level, deciding to take public transport instead of the car can save between $5,500 (if a car is kept at home and not used) and $9,400 (if using public transport avoids the purchase of a car, or second car) per year (Wang 2013).

A study of Sydney transport costs to the taxpayer found cars to be the most expensive mode of travel costing society 86c/passenger kilometre, compared with rail (the cheapest) at 47c and buses at 57c (Glazebrook 2009).

The external costs of road-based transport are significant. Globally, around 1.3 million people are killed every year by motor vehicles, and an additional 20-50 million people are seriously injured (Sims et al 2014). In Australia, the annual road toll results in around 1,200 lives lost due to car accidents (Department of Infrastructure, Regional Development and Cities 2018).

Households spend seven times more on transport than what they spend on electricity.

5. Transport climate solutions

While the transport sector is Australia's second largest source of greenhouse gas pollution, there are significant opportunities to reduce emissions through a shift to public and active transport alternatives, and to renewable-powered electric vehicles (ClimateWorks 2014; Hawken 2017).

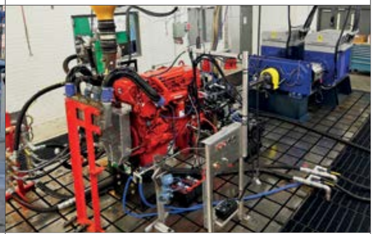
Key climate solutions to drive down transport emissions involve:

› providing viable alternatives to driving, such as expanding access to reliable, comfortable public transport, cycling and walking alternatives.

› electrifying and powering cars, buses, trains and light rail with 100% renewable energy (eg. Canberra's light rail).

› adopting policies and incentives to encourage lower emitting vehicles, such as mandatory greenhouse gas emissions standards and electric vehicle targets (Table 4).

Table 4: Transport solutions to reduce greenhouse gas pollution.

Solution	Mode shift to public and active transport alternatives	Renewable energy powered electric vehicles	Policies and incentives for more fuel efficient vehicles
			
What is it?	Increasing public and active transport use by providing viable alternatives to driving, such as high quality, efficient and accessible public transport, cycling and walking alternatives.	Electrifying bicycles, cars, buses, light rail and trains and powering them with 100% renewable energy.	Mandatory fuel emissions standards set targets for new cars to meet lower emissions (per kilometre travelled) over time. The overall emissions intensity of the car fleet is reduced over time as new, more efficient vehicles are purchased to replace older ones. Targets and incentives to drive the uptake of electric bicycles, cars and buses.
Benefits (in addition to reduced greenhouse gas pollution)	Reduced congestion Safer (reduced car accidents) More physical activity More inclusive (transport access for people without access to a car or unable to drive) Improved air quality Lower transport costs (compared to driving) Reduced public space dedicated to cars	Reduced urban air pollution and noise Electric vehicles can be powered by renewable energy Lower running costs	Covers a broad range of vehicles, driving down emissions across the entire car fleet Lower running costs
Barriers	Car oriented planning, urban design and infrastructure budgets Lack of investment in public and active transport infrastructure Requires behaviour change	Lack of charging infrastructure Lack of policy and incentives to drive take up (emissions standards/ targets) Upfront cost (offset by lower running costs) Perceptions, e.g. concerns about distance per charge	Government inaction

Sources: ESAA 2013; CCA 2014; Hawken 2017.

Globally transport solutions have the potential to significantly reduce greenhouse gas emissions by 2050 (Table 5).

Table 5: Emissions reduction potential from transport solutions.

Solution	Global emissions reduction potential to 2050 (gigatonnes CO_2e)
Mode shift	
Mass transit	6.57
Walkable cities	2.92
Bike infrastructure	2.31
Digital communications (as an alternative to travel)	1.99
High speed rail	1.42
Ride-sharing	0.32
Total	**15.53**
Renewable powered electric vehicles	
Electric vehicles	10.8
Electric trains	0.52
Electric bikes	0.96
Total	**12.28**
Greenhouse gas standards	
Cars	4.0
Trucks	6.18
Total	**10.18**

Source: Hawken 2017.

5.1 Increasing public transport use to move more people with less pollution

Mode shift from car travel to public and active transport is one of the most effective measures available to reduce transport energy use and greenhouse gas pollution. Federal and state governments can play a major role in encouraging mode shift to public transport through both infrastructure provision and efficient day-to-day service planning (such as coordinated timetables and running more frequent public transport services on existing routes).

Figure 12: Adelaide Tram.

European cities have led the shift from car travel to public transport, with Vienna, Paris, London, Oslo, Prague and Geneva increasing the share of journeys by public transport by 20% or more by increasing public transport supply and discouraging car travel (for example through parking restrictions and congestion charging). In Vienna, Austria - which recently overtook Melbourne as the "world's most liveable city" - more trips (54%) are now made by public transport than by private vehicle (UITP 2015; The Guardian 2018).

Even cities famous for their car dependent, sprawling suburban development such as Houston and Dallas in Texas, United States have been taking steps - rolling out new light rail and train systems and investing in improving bus services - to increase the use and availability of public transport (Case Study 9). The number of light rail systems in American cities has doubled since 1995. Use of public transport is growing in the United States, particularly on light rail and trains (Newman et al 2012).

Almost every capital city in Australia is now planning, building or extending new light rail or train services (The Age 2018b, e.g. Figure 12).

5.1.1 CREATING A PUBLIC TRANSPORT "NETWORK EFFECT"

An effective public transport service recognises that not all journeys - for work, education, or social activities - involve travelling to and from the city. Providing a seamless public transport service that enables people to travel from any part of the city or suburbs, to any destination in a direct, efficient and low cost way is critical to encouraging higher levels of public transport use. The key to encouraging a shift to public transport is by creating a "network effect", resembling a grid or web pattern criss-crossing the city.

Key elements required for an efficient, high quality public transport network include implementing:

- Regular, reliable and frequent services.
- A network or grid of high speed, high capacity cross-city public transport links and local feeder bus services.
- A series of well-designed interchanges, or connection points, and simple, coordinated timetables enabling commuters to quickly and easily switch from one route or mode to another.
- Integrated ticketing.
- Information, including public transport maps which are comprehensive and easy to use as well as effective signage at rail and bus stations.

(Victorian Auditor General 2014; Stone and Kirk 2017).

Real world data on cities (such as Vancouver, Canada, Zurich, Switzerland and Vienna, Austria) that have implemented this kind of public transport network, have recorded higher levels of public transport use, compared to similar cities where public transport follows a radial pattern (focused on travel to and from the city) (Stone and Kirk 2017).

This public transport "network effect" can even be retrofitted onto existing transport systems by re-designing bus routes in a way that provides efficient and direct cross-city services, to integrate with existing high capacity routes (such as rail lines) to and from the city. A number of cities around the world, and in Australia are now seeking to apply the principles of the "network effect" in redesigning their public transport systems in order to achieve higher rates of use such as Houston, Texas (Case Study 9).

5.1.2 LAND USE PLANNING AND PUBLIC TRANSPORT

The Australian Government's Smart Cities Plan promotes the concept of a "30 minute city", or one where in each part of the city it is possible to reach a major centre for work and services within 30 minutes (Commonwealth of Australia 2016c). The idea is for land use planning to design cities and their transport systems so that residents can access jobs, education, shops and recreational facilities within 30 minutes from their home. The new Sydney strategic plan *A Plan for Growing Sydney* sets out this as its basic strategic idea, and the Victorian Government's *Plan Melbourne* aims to achieve a 20 minute city (Commonwealth of Australia 2016c). Many other Australian cities have similar plans and objectives, often supported by local government planning.

However, delivering on the concept, where people have much less need for a car and many more local and cross-city transport options, is not straightforward or easy. Much of the land use in inner cities is rapidly redeveloping at higher densities due to large demand by people to live nearer urban amenities and jobs, but middle and outer suburbs are struggling to redevelop with the kind of densities needed in suburban centres that can make them viable (Thomson et al 2016).

If land use planning is conducted in isolation from transit planning then problems follow. For example, parts of Australian inner cities have been developing in the absence of additional public transport investment contributing to overcrowding on public transport. Many cities are encouraging infill development of new high and medium rise developments along existing public transport corridors in the inner city. Where such development and population growth occurs without a corresponding increase in the frequency and provision of public transport, this can further exacerbate pressures on transport systems.

A number of Australian cities are also expanding outer suburban boundaries and opening up new areas for development. This can result in the creation of outer suburbs beyond the reach of existing public transport networks. As a result, people living in outer suburbs of Australian cities often have access to fewer public transport options than inner city areas or no public transport options at all. Where public transport services do exist in these outer areas, they are often less direct, meaning longer travel times (Infrastructure Australia 2016).

When urban development (such as new apartments, shops and offices) is planned around rail stations then not only do more people have easy access to the train but they have much less need to travel in general, have shorter distances to travel by car and easier walking and cycling distance to shops and services. Such integrated developments dramatically improve the value for money for public transport projects (Newman and Kenworthy 2015).

Integrating transport planning and land development can be combined into train and land packages, and can help finance the development of public transport. This approach called the Entrepreneur Rail Model (Newman et al 2017) is how tram and train lines were first built and has been rediscovered in Japan and Hong Kong with increasing numbers of projects now attempting such partnerships in America and Australia (Newman et al 2017). This integration of transit, land development and finance is being pursued as part of City Deals with the Federal Government and suggests that some structural reform of transport systems may be underway.

5.1.3 CAPTURING "LOW HANGING FRUIT" WITH SERVICE PLANNING AND NEW TECHNOLOGY

In addition to investing in upgrading existing and building new public transport infrastructure, network planning and improved services are critical to encouraging more people to use public transport.

Australian governments have a history of investing in large public transport infrastructure projects but then failing to enact service plans to make full use of the added capacity. For example, the Melbourne City Loop was planned in the early 1970s as a measure to increase peak hour central-area train capacity, yet from the time it opened in 1981 until 2008, the number of train arrivals at Flinders Street station in the busiest hour remained below the 95 arrivals in the 1960 timetable (excluding the St Kilda and Port Melbourne lines). Following the completion of the Regional Rail Link in 2015, the number of train arrivals at Flinders Street via Newport between 8am and 9am has increased by just 1, from 11 to 12.

There are many opportunities in Australian cities to capture 'low hanging fruit' by providing additional services (more frequent buses, or rail services) on existing routes without costly infrastructure investment. For example in Melbourne, many suburban train lines have the capacity to provide service every 10 minutes all day, 7 days a week, following the example set by the Frankston and Dandenong lines. This is possible because main train lines already provide service better than every 10 minutes during peak times. For bus routes, providing additional services requires nothing more than an expanded fleet, additional depot space and drivers.

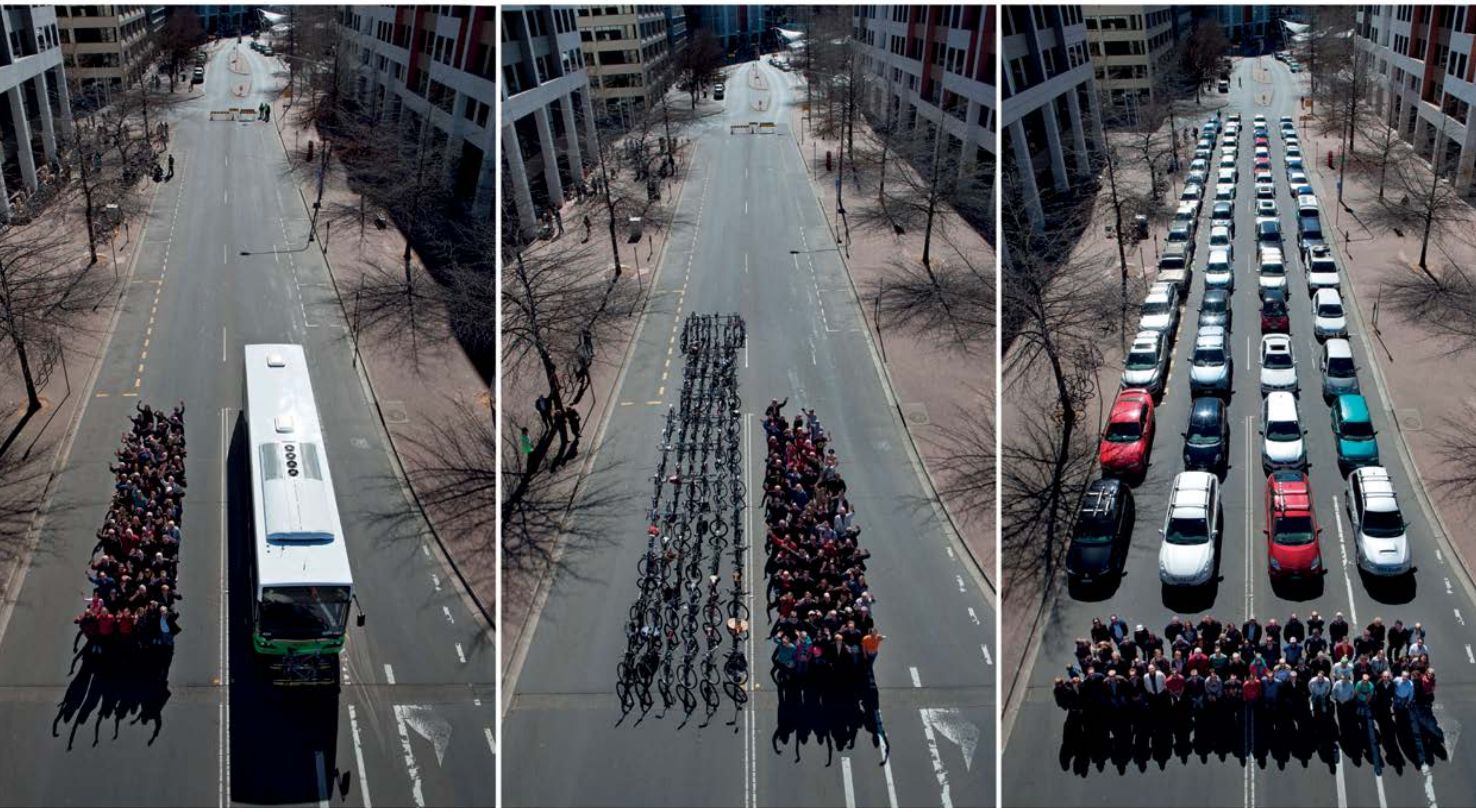
There are also a number of ways to increase the speed of buses by making their routes more direct and giving them right of way. New technology like the Trackless Tram offers ways of significantly increasing speed, ride quality and patronage without significant cost (Glazebrook and Newman 2018).

5.1.4 BENEFITS OF PUBLIC TRANSPORT

Compared to building new roads, investment in public transport is a more efficient (e.g. transporting more people, requiring less land use) way of meeting the transport needs of growing populations in Australian cities. Roads and car travel use a disproportionately large amount of land compared to public transport, especially in the inner city (e.g. Figure 13). For example, in the City of Melbourne, more than 60% of street space is dedicated to roads and car parking, even though driving only accounts for around a third of trips to the city (City of Melbourne 2018a).

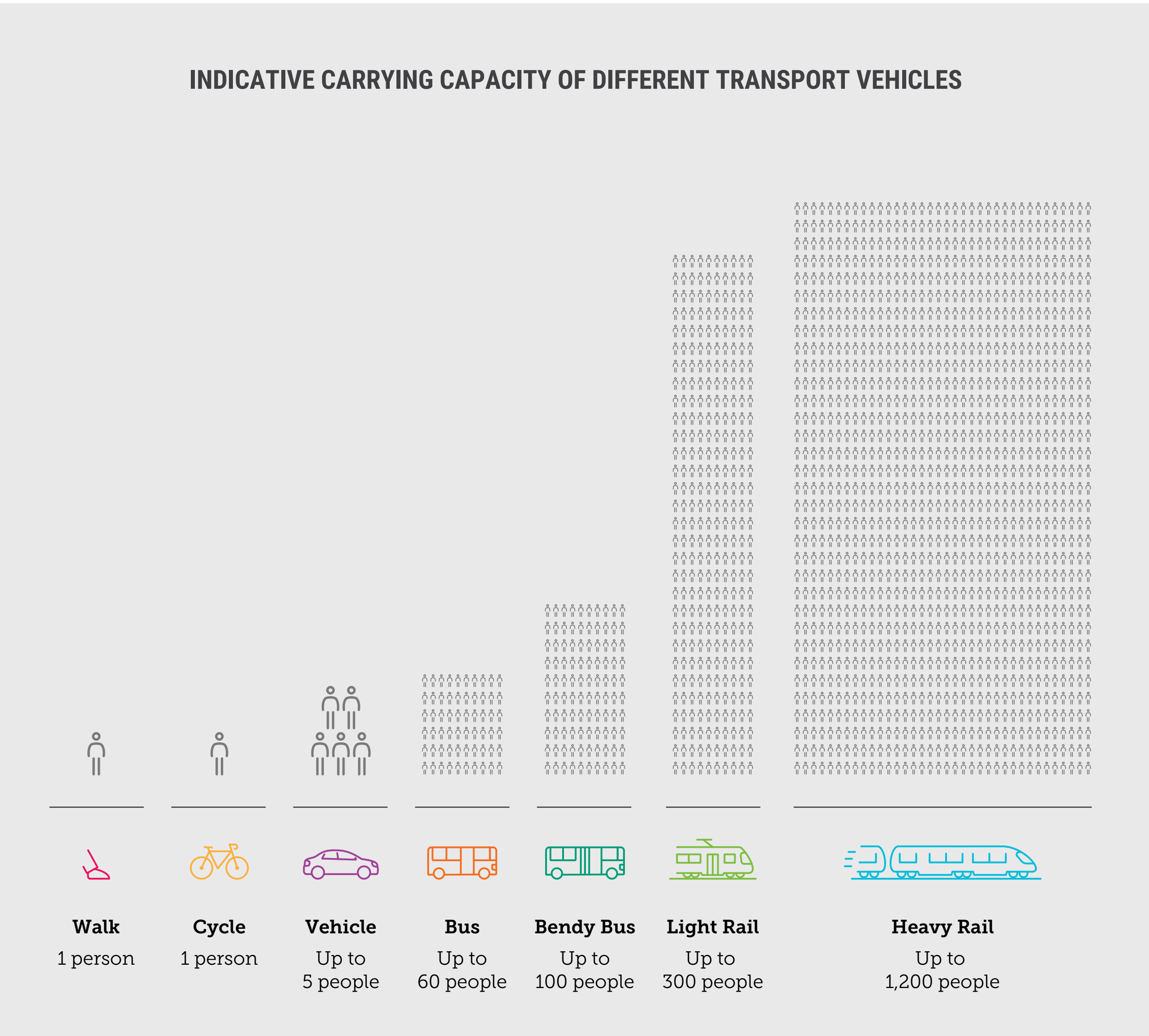
Public transport options can carry more people and require less land use compared to roads with cars carrying one or two people (Infrastructure Australia 2016; Figure 13). For example, in Melbourne, trams along Swanston Street carry more people to and from the city each day than the West Gate Bridge (City of Melbourne 2018b).

Figure 13: Cars use a disproportionately large amount of land compared to public and active transport.



Expanding access to and use of high quality public transport is a proven way to reduce car use and associated greenhouse gas pollution. People who live in communities with accessible public transport tend to own fewer vehicles, drive less and rely more on public transport than other areas (Litman 2010).

Figure 14: Carrying capacity of different transport modes.



Source: Transport for NSW.

5.2 Walkable, cyclable cities

Cities which cater for pedestrians and bike riders enable residents and visitors to minimise their need to rely on cars to get around. Australian cities have much lower walking and cycling rates than European cities (Pojani et al 2018), although much has begun to happen following the ideas of Jan Gehl (see Section 3.5).

Figure 15: Adelaide Riverbank Pedestrian Bridge.

Improving walkability and cyclability in cities requires:

› Making footpaths and bicycle lanes a standard component of transport planning (e.g. Figure 15)

› Positive messaging and political support:

  - highlighting the benefits to businesses and households from high quality walking and cycling infrastructure (and removing road and parking space to accommodate pedestrian and cycling paths).

  - encouraging people to take up active travel options

› Greater funding for active transport in infrastructure budgets. For example, in 2016 the combined national investment in cycling totalled $122 million, equivalent to less than 1% of funding for roads (Pojani et al 2018).

5.3 Renewable powered electric vehicles

While there has been significant media and public focus on electric cars, there are significant benefits of shifting to battery electric buses, bicycles and trucks as well as cars.

The source of electricity for electric car charging is critical to reducing emissions. As electric vehicle uptake grows, this must be accompanied by new, additional investments in renewable energy. As electric vehicles are an additional source of electricity demand, it is important that new renewable electricity sources for charging electric cars are additional to those that would otherwise be provided, so as not to undermine pollution reductions being made in the electricity sector.

5.3.1 RENEWABLE POWERED PUBLIC TRANSPORT

Some Australian states and cities are taking steps towards renewable powered public transport. In 2013, Adelaide led the way as the first city in the world to introduce a solar-charged electric bus operating on the city's free connector service (City of Adelaide 2013), while Flinders University is trialling an autonomous solar-powered electric bus to shuttle students from its nearby train station. A similar trial is underway at Curtin University. Canberra, a city on track for 100 per cent renewable energy by 2020, is trialling two electric buses, and is ultimately planning to transition its ageing bus fleet to electric (ACT 2018). Melbourne's tram network will soon get their electricity from large-scale solar plants in the north of Victoria (Case Study 10). New South Wales' 87MW Beryl solar project has been contracted to power Sydney's new north-west rail line (Renew Economy 2018a).

5.3.2 ELECTRIC BUSES

Electric buses offer significant benefits over their diesel and gas counterparts, which dominate inner city bus fleets in Australian cities today. While diesel buses are noisy and their exhaust is bad for health and climate change, electric buses are modern, quiet, and clean people movers. Electric buses are more expensive upfront, but with lower fuel, maintenance and running costs.

Switching from gas or diesel to battery electric buses significantly reduces greenhouse gas emissions (Dallman et al 2017). Battery electric buses produce less greenhouse gas pollution per kilometre than buses running on compressed natural gas or diesel. This is the case, even in countries like Australia where fossil fuels like coal and gas make up a relatively high proportion of electricity generation (Dallman et al 2017). As the percentage of renewable energy in the electricity mix increases, the climate benefits associated with switching to electric buses also increases.

A shift away from diesel buses can also dramatically reduce 'black carbon' emissions from diesel exhaust. Black carbon is a sooty black material that is both harmful to human health, and a potent greenhouse gas. In the atmosphere, black carbon contributes to over 3,000 times the warming over 20 years compared to carbon dioxide.

Shifting from diesel to electric buses would improve air quality, particularly in inner urban areas where there is a concentration of bus services.

Buses operating in cities are particularly well suited to switching to electric, as they have known routes and timetables. Charging infrastructure (as well as solar panels) can be readily installed on bus terminals and interchanges. Electric bus models are now available which can drive up to 1,700 kilometres on a single charge - meaning buses can operate throughout the day without needing charging (Quartz 2017)

While in some cases today, electric buses have a higher upfront cost than their diesel equivalents; electric buses are already cost-competitive with diesel over their operating life, when the substantially lower operating and maintenance costs of electric buses are taken into consideration (BNEF 2018a; WRI 2018). Furthermore, the cost of electric buses is coming down rapidly as global uptake increases. Electric buses are expected to be the same or cheaper than diesel buses by 2030 or earlier. Bloomberg New Energy Finance projects electric buses will make up nearly half of the global fleet of buses by 2025 (BNEF 2018b).

In 2017, the city of Shenzhen in China became the first major city in the world to switch its entire bus fleet to electric. Numerous other cities and towns are following suit. Fourteen major cities - London, Copenhagen, Auckland, Paris, Milan, Los Angeles, Barcelona, Vancouver, Mexico City, Rome, Heidelberg, Quito, Seattle and Cape Town have pledged to buy only electric buses from 2025 to reduce pollution (C40 2017). Many of these cities are already investing in electric buses, with Los Angeles ordering 100 electric buses while London introduced long-distance electric double decker buses (Elektrek 2017). San Francisco's transport agency will only purchase electric buses from 2025 and aims to switch its entire bus fleet to electric by 2035 (SFMTA 2018).

5.3.3 ELECTRIC CARS

Compared to petrol and diesel counterparts, electric cars bring benefits through reduced greenhouse gas pollution, reduced reliance on imported fuels, cleaner air and the potential to attract investment and jobs in vehicle manufacturing.

The source of electricity for electric car charging is critical to reducing emissions. As electric cars are an additional source of electricity demand, it is important that new renewable electricity sources for charging electric cars are additional to those that would otherwise be provided, so as not to undermine pollution reductions being made in the electricity sector. Public provision of electric vehicle charging infrastructure can ensure that these charge-points are powered by 100% renewable energy.

Electric vehicles powered entirely on renewable energy have negligible emissions, compared to an average new car (182gCO_2/km) (The ICCT 2015; National Transport Commission 2017). Charging an electric vehicle with renewable energy - be it rooftop solar panels or 100% GreenPower purchased from an electricity retailer - is substantially cheaper than the cost of fuel for an equivalent petrol car (AECOM 2015).

In most cases, charging an electric vehicle from the electricity grid results in less greenhouse gas pollution than a conventional vehicle. Even without 100% Greenpower or solar panels, charging an electric vehicle from the electricity grid results in less greenhouse gas pollution compared to a conventional vehicle, in every state except Victoria (ClimateWorks 2018).

Solar powered electric cars would seem to be a good fit for Australia, with its world-leading uptake of household solar (Australian Energy Council 2016), and high dependence on cars to get around. As more Australians put solar on their rooftops, and the proportion of renewable electricity in the grid grows, emissions associated with electric vehicles will fall further.

Shifting from diesel and petrol to electric vehicles would improve air quality, particularly in inner urban areas.

Today an electric car often costs more upfront than a conventional car. However, as global production increases, costs are coming down rapidly. By 2025, an electric car is anticipated to be similar in terms of upfront cost compared to a conventional (petrol or diesel) vehicle.

Falling costs together with supportive government policies are driving global growth in electric vehicles. Worldwide electric vehicle sales reached 1.2 million in 2017, increasing rapidly from hundreds in 2010. There are now over 3.2 million electric cars on the road worldwide (Lutsey et al 2018).

Car manufacturers are investing more than $150 billion to increase the production of electric vehicles (Lutsey et al 2018) and are aiming to achieve annual sales of 13 million electric cars by 2025 (from 1.2 million in 2017). Over 90% of global vehicle sales and production occurs in China, Europe, Japan and the United States (Lutsey et al 2018).

Governments around the world at national, state and local levels are seeking to accelerate the shift to electric vehicles. Mandatory greenhouse gas standards operating in 80% of the global car market are one factor driving the adoption of electric vehicles. In addition, specific targets to drive electric vehicle uptake have been put in place in China, California (United States), and Quebec (Canada) and are under consideration in Europe (Lutsey et al 2018).

In Australia, the adoption of electric vehicles is being held back by the lack of policy support or incentives, higher upfront cost, limited choice of available electric vehicles for sale in Australia, and the availability of public vehicle charging infrastructure (Business Insider 2017).

According to ClimateWorks, 2,284 electric vehicles were sold in Australia in 2017, around 0.2% of new cars sold that year (ClimateWorks 2018; NTC 2017). Contrast this to Norway, where 39% of all new cars sold are electric (Reuters 2018a).

In New Zealand, which has a target to reach 64,000 electric cars by 2021, new electric car sales, outstripped sales here in Australia (Table 6).

A number of countries have signaled they will move to ban fossil fuelled (petrol, gas and diesel) cars, including:

- Norway by 2025
- India by 2030
- The Netherlands by 2030
- United Kingdom by 2040
- France by 2040 (CNN 2017; ACT Government 2018).

Table 6: Australia and New Zealand electric car uptake compared.

Australia	New Zealand
2,284 new electric cars sold in 2017 Proportion of new car sales - 0.2%	3,659 new electric cars sold in 2017 Proportion of new car sales - 3.4%
7,341 total electric cars by end 2017 Proportion of total registered vehicles - 0.04%	6,209 total electric cars by end 2017 Proportion of total registered vehicles - 0.12%
No national electric vehicle target	Target: 64,000 electric vehicles on the road by 2021

Sources: ABS 2018b; ClimateWorks 2018; FCAI 2018; Motor Industry Association 2018; NZ Transport Agency 2018; Transport NZ 2018.

New Zealand's electric car sales surpasses Australia's.

BOX 2: WHAT ABOUT EMERGING TRANSPORT TECHNOLOGIES?

New transport technologies are rapidly emerging on the scene, variously referred to as 'disruptive technologies', the 'gig economy', or the 'sharing economy'. These new transportation technologies range from autonomous (driverless) vehicles, ride sourcing applications to public transport applications and bicycle share schemes. Each of these new technology driven transport options can have complex interactions with existing transport services and potentially significant positive or negative implications on greenhouse gas pollution levels.

Examples of emerging transport technologies include car-sharing services (where users can access shared vehicles rather than owning their own e.g. Flexicar), ride sourcing applications (e.g. Uber), public transport journey planning and payment applications, autonomous or driverless vehicles, bike sharing schemes (e.g. obikes) and drones.

Policy makers should consider the potential implications for individual technologies, particularly any environmental, social and economic impacts and whether proactive policy or regulation is necessary to avoid adverse or unintended outcomes.

For example, considerations may include whether individual technologies will:

- improve or worsen associated greenhouse gas pollution
- reduce or increase demand for private or public transport
- improve or worsen car dependency and congestion levels
- increase or decrease the cost of transport to individual users and society
- cannibalise existing services (e.g. traditional taxi services) or substitute for car use or for other modes such as public transport, cycling or walking
- change car ownership
- increase or decrease competition
- support or undermine public transport services
- impacts on physical activity levels
- impacts on land use allocated to private vehicles and parking
- impacts on pedestrians and bike riders
- provide transport access to vulnerable groups
- create other impacts or trade-offs, for example accessing user data, associated advertising, flow on impacts for other services and businesses, changing nature of employment conditions.

Sources: Institute for Sensible Transport 2016; Kleinman and Rohr (2018).

5.4 Policies, standards and targets

Mandatory greenhouse gas standards are government policies or regulations that require car manufacturers to reduce the emissions from new cars over time.

Mandatory greenhouse gas standards (or vehicle efficiency standards) apply to over 80% of the world's car market (including the United States, Europe, Japan, Korea, China, India, Canada and Mexico) (CCA 2014; Lutsey et al 2018). Australia is one of only a handful of OECD countries without mandatory greenhouse gas standards for vehicles (ACEEE 2018).

Australia is one of only a handful of OECD countries without greenhouse gas standards for vehicles.

The sooner mandatory emissions standards are introduced, and rapidly strengthened, the greater the impact. If strict standards are introduced, Australia can prevent up to 65 $MtCO_2$ of emissions by 2030 (Australian Government 2017). This is equivalent to the annual emissions from seven Liddell Power Stations (Clean Energy Regulator 2018). Urgency is key. Mandatory emissions standards have wider benefits, reducing fuel bills for car owners, saving an estimated $8,500 over a vehicle's lifetime (CCA 2014).

Since 2015, the Federal Government has considered in detail the introduction of emissions standards for cars and light vehicles, but the Federal Government has yet to implement any such policy.

The success of mandatory emissions standards in cutting greenhouse gas emissions relies on new lower emissions vehicles replacing existing higher emissions vehicles over time. Even with the introduction of strong mandatory emissions standards, it will be important to ensure that higher emissions vehicles are retired, or taken off the road, over time so that new vehicles (whether they be lower emissions, or electric) don't simply add to the total number of vehicles on the road, and the total vehicle-kilometres travelled.

6. Case studies

6.1 Australia

CASE STUDY 1:

Gold Coast Light Rail

The first stage of the new Gold Coast Light Rail project opened in 2014, connecting 16 stations along 13 kilometres of track. Services run at least every 15 minutes on weekdays. Already the light rail project has carried 21,000 passengers on average every day, and contributed to 23% growth in public transport use between 2015 and 2016.

The project has also reduced vehicle traffic on the Gold Coast Highway at Broadbeach by 21% (City of Gold Coast 2017). Stage 2 of the light rail opened in December 2017, extending the line by a further 7.3km (Gold Coast Light Rail 2017).

This is just the first of several stages, as part of the Gold Coast City's Transport Strategy 2031.

Figure 16: The Gold Coast light rail has reduced vehicle traffic on the highway at Broadbeach by 21%.

CASE STUDY 2:

Electric Buses Driving New Manufacturing Jobs in Adelaide

In July 2017, the first Australian designed, engineered and manufactured electric bus rolled off the production line and onto Adelaide's streets, becoming part of Adelaide's public transport network. The success of this project has seen the manufacturers Precision Buses contracted to produce 50 more low carbon buses for New South Wales, Queensland and Victoria. This will increase the number of employees at the organisation from 29 to 79 (Business Insider 2017).

CASE STUDY 3:

ACT Zero Emission Vehicle Action Plan

The ACT Government is on track to achieve 100% renewable electricity by 2020, and has a target to reach net zero emissions before 2050. With transport a key source of greenhouse gas pollution in the ACT, the Government has released an action plan to dramatically reduce greenhouse gas pollution from vehicles as well as encouraging people to walk, cycle and use public transport instead of driving.

The ACT Government has already undertaken a number of actions including:

- Transitioning the ACT Government fleet to zero emissions vehicles. The ACT Government now has 17 electric vehicles, 7 plug-in hybrid vehicles, 62 hybrid vehicles and 8 electric bikes
- Trialling battery electric buses on a number of routes throughout Canberra
- Investigating hydrogen vehicles
- Encouraging the rollout of public charging infrastructure

Future actions include:

- All newly leased ACT Government vehicles will be zero emissions from 2020-21
- Investigating covered car parks with solar powered vehicle charging stations
- Creating incentives for zero emissions vehicles such as parking priority and ability to drive in transit lanes (ACT Government 2018)

CASE STUDY 4:

Queensland Electric Vehicle Superhighway

The Queensland Government have recently rolled out stage one of what they claim to be the world's longest electric vehicle highway in a single state. The project came online in January 2018 and connects Coolangatta in the south east of the state to Cairns in the far North. All of these chargers are superfast DC chargers and most of them have been installed by Brisbane-based company Tritium. Tritium's DC chargers can charge an EV battery in as little as 10 minutes (Reneweconomy 2018b).

This project enables long distance trips to be undertaken in electric vehicles across Queensland. Further charging stations will come online later this year (Reneweconomy 2018b).

CASE STUDY 5:

Melbourne's Solar Powered Tram Network

Victoria's tram network is one of the largest in the world, with 200 million boardings every year (Yarra Trams 2018). The entire tram network will soon be powered by 100% renewable energy, with the construction of 138MW of solar capacity by the end of 2018. The Bannerton and Numurkah solar farms in northern Victoria are being built after winning a Victoria government tender in 2017 (Premier of Victoria 2017).

Figure 17: Melbourne's trams will soon get all their electricity from solar plants.

CASE STUDY 6:

Adelaide's World First Solar Electric Bus and electric vehicle charging stations

Adelaide is home to the world's only pure electric bus powered entirely by solar energy. Unlike other solar powered transport, the "Tindo" bus does not have solar panels on its roof. Instead it is recharged by energy from solar panels on the roof of the Adelaide Central Bus Station. The bus runs on Adelaide's free connector bus service every day (City of Adelaide 2013).

The City of Adelaide installed 19 fast-charging stations in the Central Market precinct in 2017. These charging stations are DC chargers. This means they can fully charge an electric vehicle with a range of 52 km (eg. Mitsubishi Outlander) in just 30 minutes. Tesla Superchargers have also been installed, which can charge a Tesla Model S and Model X with a range of 270 km - in just 30 minutes. The Tesla Superchargers will eventually be rolled out across South Australia and enable a Tesla car to travel from Adelaide up to Brisbane (Premier of South Australia 2017).

A further 25 charging stations will be installed throughout the city by mid-2018 (Premier of South Australia 2017).

Figure 18: Adelaide's world-leading solar electric bus.

CASE STUDY 7:

Sustainable Transport Moreland, Victoria - integrated transport strategy

The city of Moreland in inner urban Melbourne has developed an integrated strategy for transport which aims to achieve a shift to more environmentally sustainable travel behaviour; support transport access for all parts of the community; and improve safety and support development around transport hubs (with access to trains, trams, bicycle and walking paths) in Moreland.

Moreland supports car sharing services for residents who don't own a car. In 2012, the council installed Victoria's first electric vehicle charging station, it now has three charging points throughout the city, and is integrating electric cars into its council fleet (Figure 19). The council has strategies to encourage walking, cycling and public transport in Moreland (City of Moreland 2017).

City of Moreland installed Victoria's first electric vehicle charging station.

Figure 19: One of Moreland City Council's electric vehicle charging points.

6.2 International

CASE STUDY 8:

Sustainable transport Washington, D.C. - transport targets and actions

In 2012, Washington DC (population 643,000), embarked on an ambitious and comprehensive plan "Sustainable DC", to tackle the city's key sustainability challenges of jobs and economic growth; health and wellness; equity and diversity; and climate and environment (Sustainable DC 2016). The plan includes a target for 50% of city's power use (both council operations and the community) to come from renewable energy sources by 2032.

Transportation was identified as one of the Sustainable DC plan's seven key areas. Specific targets were set for trips within the city by 2032 - with car travel to decrease to less than 25% of trips, public transport trips to increase to 50%, and biking and walking to increase to 25%. The goals and targets were underpinned by a detailed action plan (Table 7).

As a result of its actions, 2016 saw Washington DC become the equal first out of 50 US cities (tied with Boston) for the proportion of commuters walking or cycling, and second best (after New York) when public transport was included (Alliance for Biking and Walking 2016). The city was one of two major cities (with Portland, Oregon) to make a significant gain in the share of commuters biking and walking (Alliance for Biking and Walking 2016).

Nearly 39% of Washington DC residents now commute by public transport, nearly 13% walk and 4% ride (Alliance for Biking and Walking 2016). These shares are significantly higher than the average mode shares for Australian cities - 14% by public transport, 3.8% walk and 1.3% ride on average (Australian Government 2013).

Figure 20: Washington DC Capital bike share scheme.

Table 7: Sustainable DCs Transportation Goals, Targets and Actions.

Goals	Targets	Actions
Improve connectivity and accessibility through efficient, integrated, and affordable transit systems	Increase use of public transit to 50% of all commuter trips	› Complete 60 kilometres of tram networks › Improve transit connections to employment and activity centers from underserved areas › Define and secure permanent funding for transit planning and improvements › Design transit systems for resilience to extreme weather events
Expand provision of safe, secure infrastructure for cyclists and pedestrians	Increase biking and walking to 25% of all commuter trips	› Develop a citywide, 100-mile bicycle lane network › Expand the Capital Bikeshare program by 200 stations › Partner with community organizations to deliver bike and pedestrian safety education › Collect data to improve understanding of cyclist and pedestrian travel patterns › Program crosswalks and traffic lights for improved safety and convenience of pedestrians and cyclists
Reduce traffic congestion to improve mobility	Reduce commuter trips made by car or taxi to 25%	› Implement an expanded Performance-Based Parking program › Expand car-sharing programs to low-income residents using financial tools › Encourage private businesses to offer incentives for employee travel by transit, walking, or biking › Encourage and promote telecommuting and alternative work schedules for employees › Study the feasibility of a regional congestion fee for travel during peak hours
Improve air quality along major transportation routes	Eliminate all "unhealthy" air quality index days, including "unhealthy for sensitive groups"	› Strictly limit idling engines. › Require District Government, and encourage private businesses, to purchase clean fuel, low-emission fleet vehicles. › Expand electric vehicle charging infrastructure throughout the city › Offer incentives to avoid driving and other emission-generating activities on predicted Code Red and Orange air quality days › Track and report mileage data from clean fuel, low-emission, and electric vehicles

Source: Sustainable DC 2016.

CASE STUDY 9:

Houston bus network re-design

Houston is often regarded as one of the world's most car-dependent cities. Three years ago Houston made dramatic changes to the design of its bus network in order to encourage more commuters out of their cars and onto public transport.

In 2015, the Houston Metro completely redesigned the city's bus network, routes and timetables. The transformation involved shifting away from a system where most routes ran to and from the city, to a grid network of bus routes cutting across the city, with more frequent services.

Key elements of the redesign included:

- More frequent buses running at least every 15 minutes along major routes
- Routes and timetables that enable commuters to easily transfer from one route to another
- More predictable buses run on the same schedules on weekdays and weekends
- New routes following a grid pattern enabling people to more easily and directly travel to and from a greater range of locations across Houston (not just the city centre) (Mobility Lab 2018).

Prior to the re-design, the bus service had experienced a 20% decline in patronage between 2007 and 2011 (Mobility Lab 2018).

The bus network overhaul is widely judged to have been a success with local bus and light-rail systems recording a gain of 4.5 million boardings – an increase of 6.8% - between September 2015 and July 2016 (City Lab 2016). Bus ridership on Saturdays and Sundays has increased even more, with 13% and 34% increases respectively (City Lab 2016). Houston is one of only two United States cities (along with Seattle) to increase bus patronage in the last three years.

Figure 21: Houston Metro Re-design - before and after.

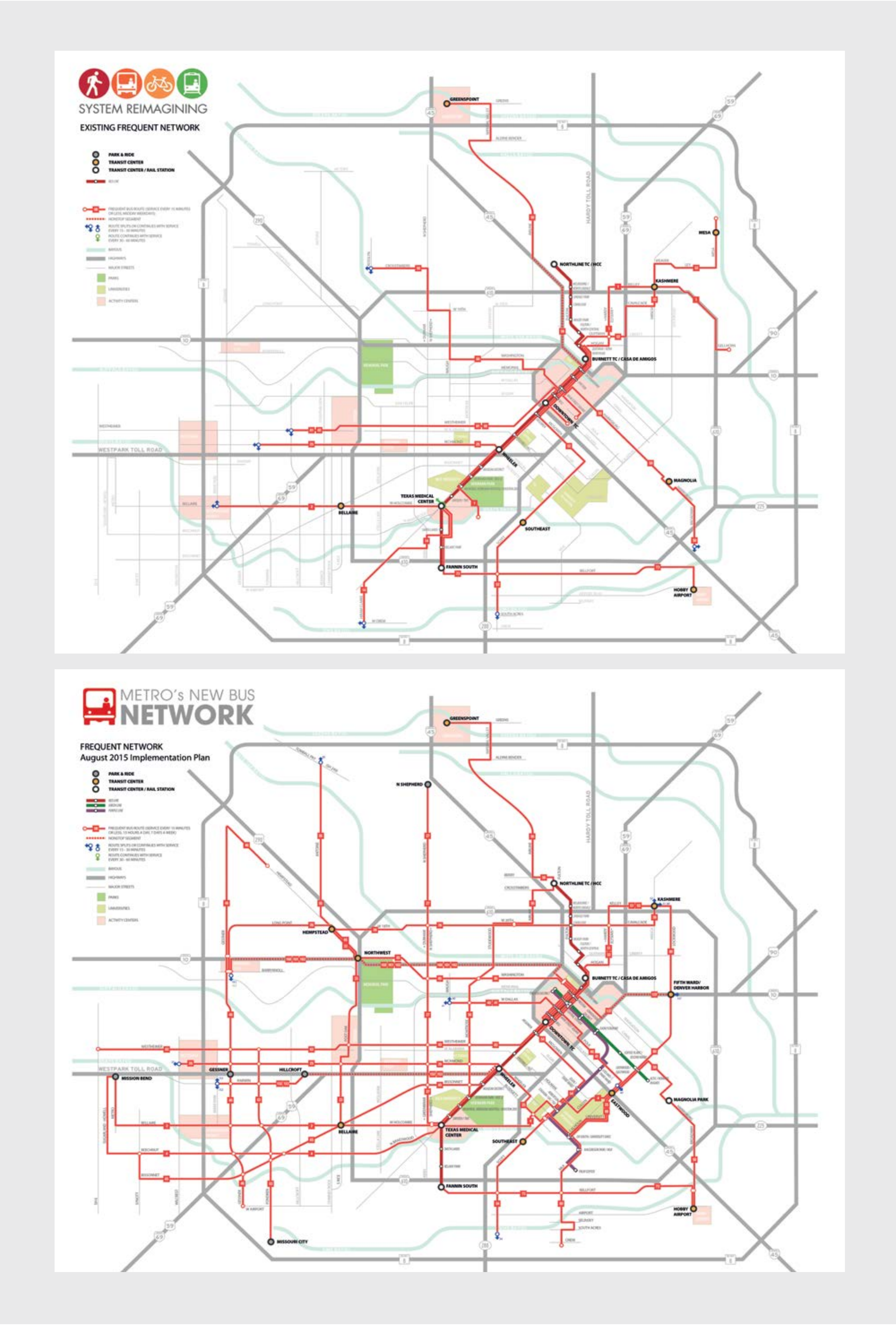


Figure 22: Aucklands Nelson Street cycleway.

CASE STUDY 10:

New Zealand Urban Cycleways Programme

The New Zealand Government is investing NZ$333 million on cycling infrastructure through its Urban Cycleways Programme. The program is funding over 50 new cycleways, with 36 of the projects completed or under construction.

The completed cycleway projects are already encouraging an increase in cycling, for example in Christchurch there has been a 21% annual increase in people riding their bikes into the city (New Zealand Government 2017).

Figure 23: Inside a train in the Shanghai metro.

CASE STUDY 11:

China's Train Metro Network

Since 1995, the number of Chinese cities with metro lines has increased from 1 to 25 and that number is still rising. Across the country, there are now more than 5,000 kilometres of metro lines (not including commuter services between cities and the country's extensive high speed rail network) (The Transport Politic 2018).

This investment has led to massive increases in public transport use. Ridership on Beijing and Shanghai's metro systems alone has doubled since 2010 (The Transport Politic 2018).

A recent study by Gao and Newman (2018) has shown that Shanghai and Beijing have both peaked in private car use per capita as both Metros have grown so popular. The result has been a decoupling of economic growth from car use, showing how it is feasible to enable the transition to low carbon options without losing jobs and economic opportunities.

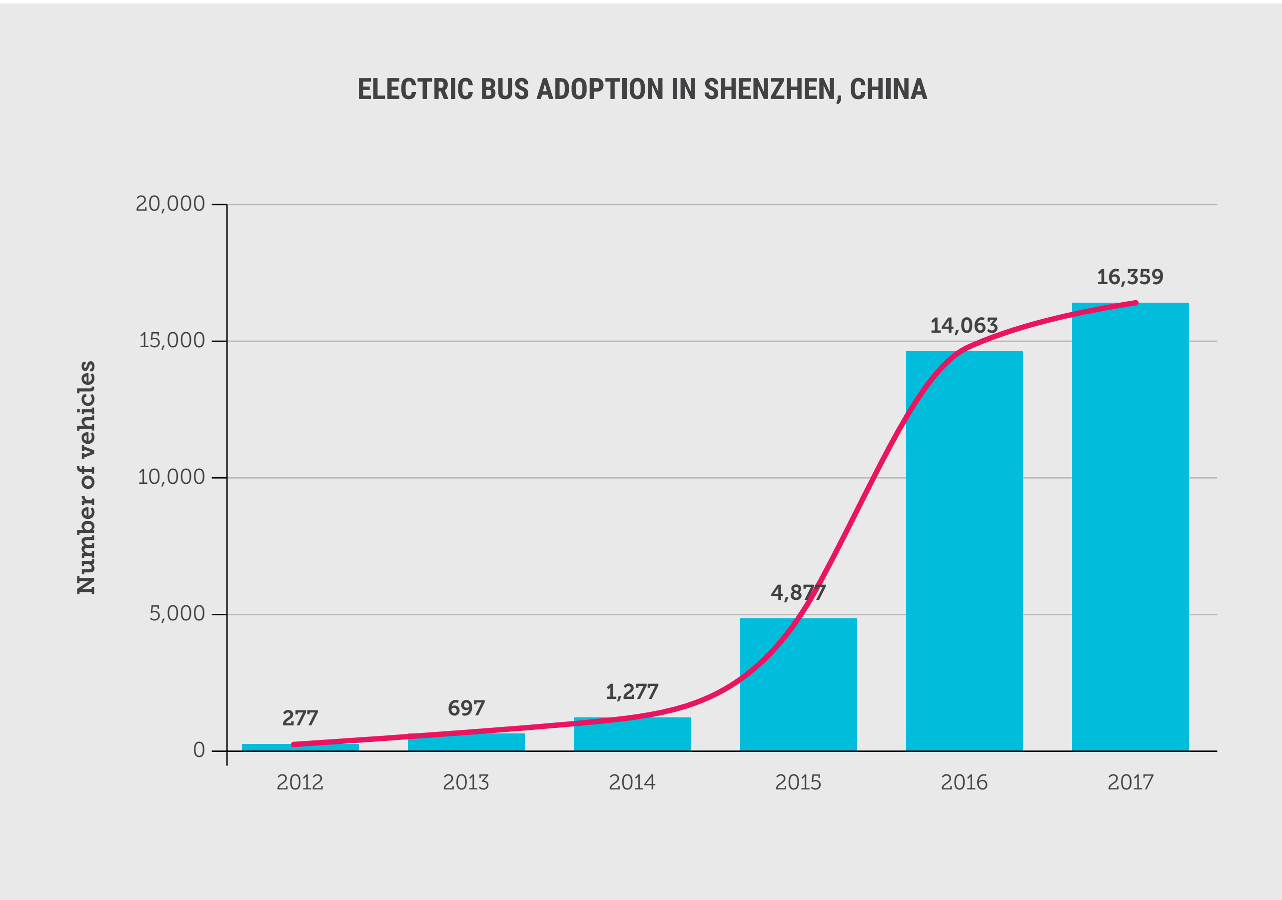
CASE STUDY 12:

Shenzhen, China - world's first fully electric bus fleet

China is leading the global rollout of electric buses, with over 300,000 on the road at the end of 2017. In the Chinese city of Shenzhen, the city's entire 16,000-strong bus fleet was converted to electric vehicles by the end of last year. The replacement of the city's diesel bus fleet began with a pilot in 2011 – just 7 years ago. Now, the city of 11.9 million people – half the size of Australia – is entirely serviced by electric buses (CleanTechnica 2017).

Figure 25: One of Shenzhen's electric buses being charged.

Figure 24: Electric bus adoption in Shenzhen, China.



Source: WRI 2018.

CASE STUDY 13:

Santiago's Public Transport Powered by Solar

The public transport system in Santiago, the capital of Chile in South America, will be run almost entirely on solar energy, after a power purchase agreement was signed to supply the system with solar power. The agreement will support the construction of a 100MW solar farm that will begin operating in 2018. This will massively reduce pollution from Chile's public transport system, which currently transports 2.2 million passengers a day (CleanTechnica 2016).

CASE STUDY 14:

One Third of New Zealand Government Cars to be EV's

The New Zealand Government has pledged that one-third of the government car fleet will be hybrid or electric by 2021. The Government currently has 15,500 vehicles, so by 2021, it will have 5,000 hybrid or electric vehicles. This will contribute to New Zealand's plan to have 64,000 electric vehicles by 2021 (National 2017).

Currently New Zealand has just 4,200 electric vehicles, although this is significantly higher than in May 2016, when just 1,300 vehicles were electric (National 2017).

Figure 26: A view of Santiago's metro train line, which will soon be powered by solar.

CASE STUDY 15:

California Aims for Five Million Electric Vehicles

California has ambitious plans for electric vehicles, with a target for 1.5 million by 2025 and 5 million by 2030 (Reuters 2018b). The state is already on its way to meeting the 2025 target, with the second largest EV market in the world consisting of over 300,000 fully electric and hybrid vehicles (Forbes 2017). Importantly the EV target is accompanied by other policies, such as the addition of 250,000 vehicle charging stations and 200 hydrogen fuelling stations by 2025 - at a cost of $2.5 billion (Reuters 2018b).

Strong, clear policies like California's EV targets have motivated car makers to build dozens of new EV models (Reuters 2018b).

CASE STUDY 16:

India Plans for EV Future by 2030

In order to deal with poor air quality and pollution, India plan to phase out the sale of all diesel cars by 2030. This ambitious target would require around 10 million electric cars to be sold in 2030 - dwarfing the global total of electric cars in 2015 (which stood at just 1.3 million). In 2016, there were just 5,000 EV's on Indian roads (Bloomberg 2017).

Along with significantly reducing toxic pollution and CO_2 emissions, the plan would also significantly cut India's oil imports (Bloomberg 2017).

Figure 27: Electric Vehicles in India.

CASE STUDY 17:

Electric Car Targets in Europe and beyond

There is a range of countries in Europe that have set up electric vehicle targets including Germany, France, the United Kingdom, Spain, Denmark, Ireland, Austria, Portugal and the Netherlands. These targets vary from the partial uptake of electric cars to the complete replacement of petrol and diesel cars (IEA 2017a).

Eight states in the United States have also introduced electric car targets, as have China, Japan, South Korea and India (see above). Combining all these targets, the International Energy Agency estimates that 13 million electric cars will be deployed amongst these countries by 2020 (IEA 2017a).

CASE STUDY 18:

Car Companies Building a European Charging Network

Volkswagen, BMW, Ford and Daimler (part of Mercedes) are starting construction on a $50 billion fast charging network along highways across Europe. The companies plan to have 100 fast charging stations in place by the end of 2018 and 400 by 2020. This project will enable owners of electric cars to make transcontinental journeys without having to worry about where to charge their cars (Automotive News Europe 2018).

This project builds upon the leadership shown by a range of European countries. Germany has already developed a comprehensive charging network that includes 8,515 charging outlets. This is one third higher than the 2016 total (Automotive News Europe 2018).

7. Conclusion

Now is Australia's opportunity to cut greenhouse gas pollution from transport while moving people in our cities more efficiently, reducing urban air pollution and noise and saving commuters money.

Australia's growing cities are starting to see breakdowns in the performance of the current transport systems. Stress, congestion, air pollution, noise, ever increasing public space dedicated to roads, and the high cost of private transport are all exacerbated by our current reliance on roads and high polluting cars.

Cities around the world are fast-tracking transport solutions to climate change with three key strategies for reducing pollution from the transport sector:

1. Avoiding or reducing the need to travel. This can be achieved through improved telecommunications and urban planning.

2. Providing viable alternatives to driving, such as expanding access to reliable, comfortable public transport, cycling and walking alternatives.

3. Reducing pollution across transport modes and vehicles. This can be achieved by electrifying and powering cars, buses, trains and light rail with 100% renewable energy. In addition, policies supporting stringent, mandatory greenhouse gas emissions standards for cars and other vehicles (and strengthening these over time) could be adopted.

It's time for Australia to get on board with transport solutions to climate change.

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