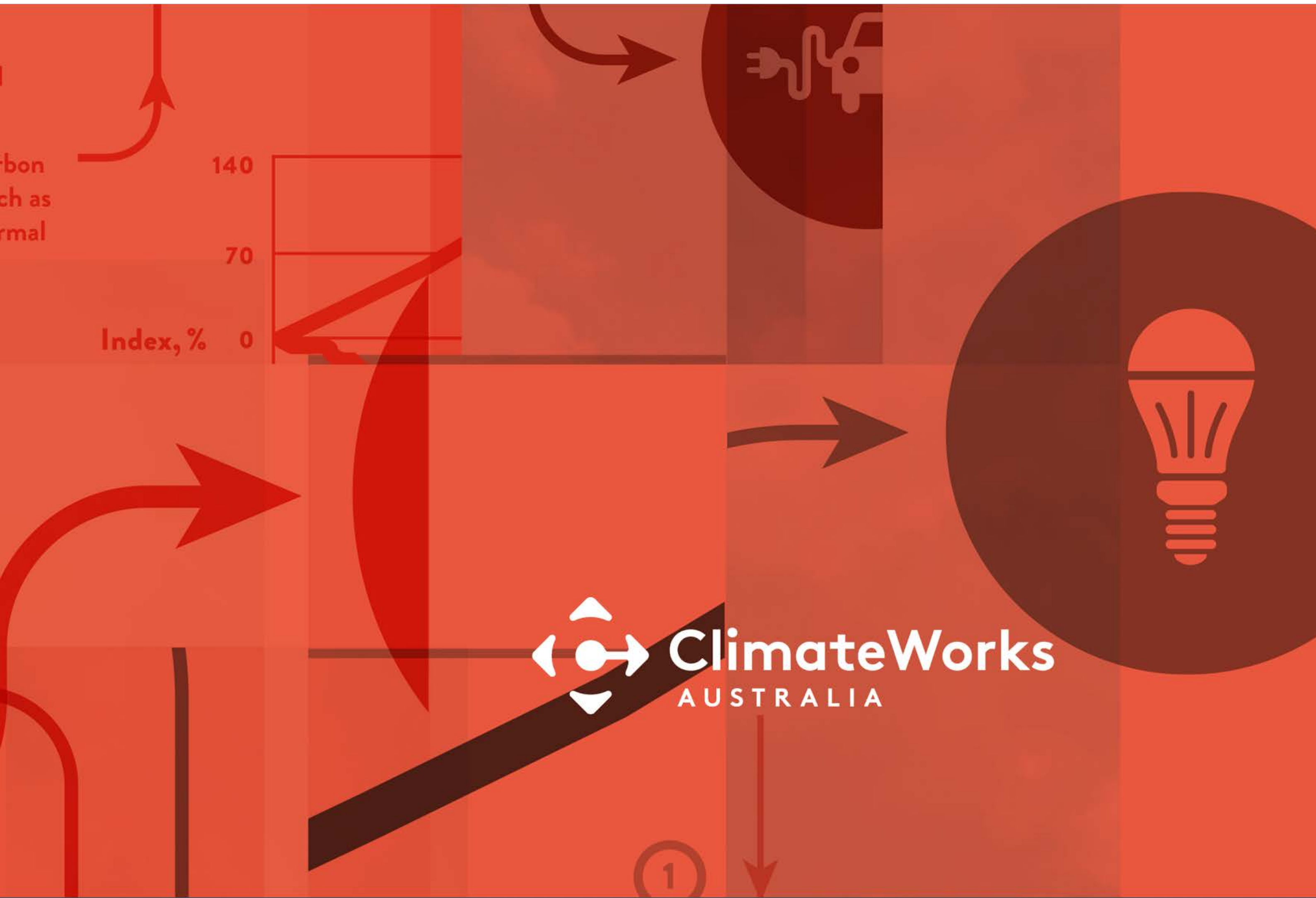
REPORT

The future of private transport in Australia

Examining potential environmental impacts as part of an interdisciplinary research project across Monash University

December 2017



Founding partners Monash University and The Myer Foundation

ClimateWorks Australia
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About us

ClimateWorks Australia

ClimateWorks Australia is a leading independent organisation acting as a bridge between research and action to identify, model and enable end-to-end solutions to climate change.

Since our launch in 2009, ClimateWorks has made significant progress and earned a reputation as a genuine and impartial adviser to key decision makers from all sides of politics and business. Our collaborative approach to solutions that will deliver the greatest impact encompasses a thorough understanding of the constraints of governments and the practical needs of business.

We do this by looking for innovative opportunities to reduce greenhouse gas emissions, analysing their potential, resolving obstacles and helping to facilitate conditions for our transition to a prosperous, net zero emissions future by 2050.

ClimateWorks was co-founded by The Myer Foundation and Monash University and works within the Monash Sustainable Development Institute.

This report forms a chapter within a broader project undertaken by a collaboration between Monash Research partners, to explore current knowledge and gaps in research around the future of private transport in Australia. This chapter, led by ClimateWorks Australia, focuses on potential environmental impacts of future transport.

Contents

1. Introduction

The future of private transport is likely to be defined by the emergence of 'new mobility', as the development of new technologies intersects with the evolution of new and existing business models (International Council on Clean Transport (ICCT) 2017b). As the transport sector evolves, there is the potential to move people and goods in a more efficient, safe and sustainable way (Smith, Clayton and Hanson 2017). However, a challenge remains in how to ensure that changes to the sector deliver these positive outcomes and mitigate potential negative impacts.

Governments and regulators across all levels need to prepare for and develop policy that shapes the rapidly changing transport system, rather than reacting to new developments after the fact (ICCT 2017b). This will ensure that this evolving sector is shaped to deliver positive environmental and social outcomes.

New mobility concepts and technological disruptors are no longer decades away, with many already beginning to shape the way people travel from one place to another. New technologies involve alternative fuel and electric vehicles, partially or fully self-driving vehicles, and vehicles that communicate electronically with each other and infrastructure. New transport business models include services that provide mobility on demand, Mobility as a Service (MaaS), or shared mobility.

This interdisciplinary project addresses the burgeoning area of the future of private transport in Australia, covering areas of Monash University's interests and expertise, including injury prevention, new vehicle technology, vehicle design and engineering, driver behaviour, environmental impact, information technology, increased efficiency and cost savings, and vehicle law and regulation.

In this report, we consider the future of private transport through the lens of greenhouse gas emissions and energy. While the major emerging trend of vehicle electrification will reduce emissions and improve energy productivity, other trends, specifically autonomous vehicles and MaaS, could have either positive or negative environmental impacts. This report is intended to help identify policy approaches to ensure that new mobility develops in a way that delivers positive environmental outcomes.

The report has been written with an aim to provide a high level overview of major trends, rather than a comprehensive assessment, and to highlight areas for further research. The focus has been primarily on the Australian market and relevant international developments.
For Australia to ensure that the transformation of mobility has positive impacts for the environment, further research is required in a number of areas. Recommendations for further study are included throughout the report and summarised in Section 5, with linkages drawn between other work packages of the broader interdisciplinary project.

2. Our current transport system

Globally, transport needs are increasing. The need for an advanced 21st-century network of roads, airports, shipping facilities, train routes, and public transport is crucial to ensure connectivity between cities, communities, and rural areas. Investment in transport infrastructure is working to support this need, with increased expenditure going into the development of new transport systems as well as upgrades and extensions of older ones.

However, a challenge remains in how to best move people and goods in the most efficient, safe and sustainable way - while at the same time, resolving accessibility issues and providing transport for all segments of society (Smith, Clayton and Hanson 2017). With an increasingly globalised, urbanised, digitised, and environmentally compromised world, new methods and technologies for the transport of both people and goods is required.

2.1 Inefficiencies with the current transport system

The 20th century saw the rise of several significant revolutions in mobility and transport systems; most notably the internal combustion engine (ICE), mass production of automobiles, high speed urban and interurban rail systems, and construction of major road networks (Fulton, Mason and Meroux 2017). Innovation slowed in the latter part of the century and currently, the majority of people still move around cities primarily in vehicles with petrol or diesel engines and often with the only occupant serving as driver.

Globally, private mobility is associated with increased economic output and higher standards of living (Ecola, Rohr, Zmud, Kuhnimhof and Phleps 2014). Private vehicle-based mobility is still the preferred form of transport, and sales data supports this with continued demand for new vehicles both globally and within Australia.[1] The NRMA has stated that the mindset of 'auto mobility' is an entrenched ideal within Australian society, with the ownership and usage of a vehicle to be "viewed as safe, comfortable and peaceful compared to active or public transport" (NRMA 2017).

There are however, problems with the long-term practicality of the current private vehicle-based mobility mindset. Global population is growing, and is combined with a shift in population into rapidly-expanding urban areas. In 2014, just over half of the world's population lived in urban areas, and this is expected to increase to approximately 66 per cent by 2050 (United Nations Department of Economic and Social Affairs 2014). These trends are also being reflected in Australia. Population growth combined with greater urbanisation, densification and increasingly complex travel patterns are leading to issues with congestion and a lack of appropriate infrastructure.

RECOMMENDATIONS FOR FURTHER RESEARCH:

- How the Australian context for the future of private transport differs from other international locations, including an investigation into the Australian policy context and geographical features of Australian cities.
- What are the likely environmental impacts of changes to transport congestion, usage and infrastructure in Australia by 2030?

[1] 88.1 million new passenger and light commercial vehicles were sold worldwide in 2016, an increase of 4.8% from the previous year (Scutt 2017).

Congestion

The growth in urban populations, and equally the increased levels of vehicle ownership, will continue to place significant pressures and constraints on existing urban road and transport networks.

Congestion is already a significant issue and will continue to be a challenge for future transport networks. The Department of Infrastructure and Regional Development estimates that the preventable cost of congestion in Australia is set to increase from $16.5 billion (from a 2015 baseline) to $37 billion by 2030 (Department of Infrastructure and Regional Development 2015).

Usage

While Australian cities have relatively low population densities, there is a high dependency on private transport rather than public transport when compared with overseas cities (Department of Infrastructure and Transport 2013). Despite some recent increases in public transport modal share, metropolitan passenger travel remains dominated by private road vehicles. Road vehicles, including cars, motorcycles and the non-freight use of commercial road vehicles, accounted for approximately 86 per cent of total travel across the 8 capitals in 2014 (Bureau of Infrastructure, Transport and Regional Economics (BITRE) 2015).

Since 2005, private vehicle ownership has continued to rise, in line with population growth, whereas vehicle passenger-kilometres travelled per person in capital cities has fallen. Transport adviser Paul Barter, recently analysed the average usage of private vehicles in a number of countries and concluded that depending on the city, a private vehicle will sit idle for between 92 and 96 per cent of the time (Barter 2013).[2]

Infrastructure

In a business as usual approach, there will be a need for greater availability and capacity of transport and road infrastructure than our cities currently offer. Existing forms of mobility, both road and public transport, require significant expenditure from governments.

It has been argued that new road infrastructure projects are not always an answer, particularly in developed countries which need to factor in growth and fiscal constraints. The default approach for many cities and emerging nations over the past several decades, has been to respond to driver needs with increased construction; however more and more, this strategy has resulted in increased traffic. New routes generate an increase in the number of people travelling by car and rapidly become just as congested as established routes (Williams and Hammond 2015).

In many cases, mass transit systems are also currently falling short. These systems require substantial upgrades that present an attractive alternative for commuters and also ensure any investment is delivering the best possible benefit (Williams and Hammond 2015).

2.2 Emerging policy and consumer behaviour trends that will shape the future of private transport

The future of private transport and new forms of mobility are no longer decades away, but rather there are already signs of disruption occurring. New or tightening regulations, changing consumer preferences, and technological breakthroughs are all paving the way for a fundamental shift in individual mobility behaviour.

As it stands, fuel efficiency standards currently regulate over 80 per cent of the global light vehicle automotive market (ICCT 2015a). These efficiency and carbon dioxide (CO_2) regulations have been used as a primary policy mechanism to meet Paris Agreement targets and to reduce vehicle emissions and energy use, however they have also been developed specifically for ICE vehicles. With predictions of far greater deployment of electric vehicles in the next two decades,

[2] Barter tested three different approaches: first using data on the number of car trips and their average time, then survey results about the time we spend driving, and finally extrapolates from reports on the distance and speeds cars travel.

a number of governments including the United States and in Europe are beginning to consider how best to integrate electric vehicles within the standards (ICCT 2017a). In addition, a number of countries and individual states are considering and implementing new mobility regulation; specifically establishing definitions and rules for autonomous vehicles around testing on public roads and liability. As mobility services and technologies become more prevalent in the market, policymakers have an opportunity to shape development towards a low-carbon and socially equitable outcome, which would be unlikely to occur without guiding policy (ICCT 2017b).

The majority of consumers currently use their private vehicle for all purposes, whether commuting to work alone or going on holidays with the whole family. As mobility changes into the future, there could be an increasing value placed on the flexibility to choose the best vehicle or mobility option for the specific activity. There are already early signs that the importance of private vehicle ownership is declining, while the importance of shared mobility is increasing. For example, in the United States the share of people aged 16 to 24 years who hold a driver's license decreased from 76 per cent in 2000 to 71 per cent in 2013 (McKinsey & Company 2016). This trend has also been seen in Australia: in Victoria, the number of drivers under the age of 25 without a licence has increased by 10 per cent in the last 10 years to 35 per cent, and in NSW, the proportion of young drivers has fallen by approximately one per cent per year (Clay 2014).

2.3 Current availability of transport technologies

Technological developments, new business models and digital disruption have already begun shaping the way people travel from one place to another. This section outlines some of these technologies and their current readiness for uptake.

Electrification

Electrification of private and public transport vehicles is a key first step to unlocking future mobility technologies, including autonomous vehicles. Electric vehicles are now a readily available technology, with more than 2 million electric and plug-in hybrid passenger vehicles on global roads in 2016. Globally, the number of electric vehicles sold each year is growing rapidly, with a 40 per cent increase from 2015 to 2016, to reach sales volumes of over 750,000 in 2016 (IEA 2017).

In locations with supportive policy, uptake of electric vehicles has grown rapidly. This is expected to continue into the future, with California and China both implementing zero emission vehicle mandates that require manufacturers to produce more electric vehicles or purchase carbon credits from those doing so (Marshall 2017). A number of countries have also announced plans for a ban on the sale of petrol and diesel vehicles; both France (Felix and Carraud 2017) and the United Kingdom (Castle 2017) will phase out ICE vehicles by 2040. In contrast Australians only purchased 701 plug-in hybrid electric vehicles, and 668 fully electric vehicles in 2016, making up 0.1 per cent of the Australian market (ClimateWorks Australia 2017a). The low sales volumes may be linked in part to the limited number of lower priced models available in 2016, and governments are attempting to encourage greater growth through supporting policies.

Electrification and the development of other alternative fuelled vehicles could also play a significant role in other modes of private mobility including public transport. In relation to public transport, electric buses are increasingly replacing diesel buses in response to energy policies and environmental requirements (Tourism and Transport Forum 2017). The global electric bus fleet is estimated to have reached approximately 173,000 in 2015; China is leading this global mass deployment with more than 98% of uptake (ZeEUS 2017). In Australia, the ACT Government has introduced two new electric buses and one hybrid electric bus into their public transport system as a part of a 12 month trial. The two electric buses are able to drive approximately 430 km per charge on route operations, and will be recharged overnight at charging stations at the depot (Vorrath 2017).

Autonomous technology

The technology to automate vehicles is improving rapidly. Many vehicles already come equipped with semi-autonomous technologies and a number of manufacturers are investing substantial capital in developing fully autonomous vehicles.

There are a number of levels of autonomous technologies, with SAE International outlining six levels of autonomy to describe the progression from a manually operated vehicle to a fully autonomous Level 5 vehicle. The SAE index is the globally accepted standard for autonomous vehicle development (SAE International 2014), and these categories are outlined in Table 1 below, as adapted from the International Council on Clean Transport (ICCT 2017a).

Autonomous technologies are already entering the private vehicle fleet, and are currently in the form of self-parking, autonomous braking and lane guidance technologies (NRMA 2017). These types of technologies represent autonomy levels 0 to 2.

The development of driverless vehicle technologies is being led by major tech companies such as Uber, Google and Tesla. These companies have ambitious plans for the development of autonomy. For example, Ford aims to have a fleet of high-volume, shared autonomous vehicles on the road by 2021, and all Tesla vehicles are now equipped with hardware that will allow full autonomy in the future, once regulatory barriers are overcome (ICCT 2017b).

There are several autonomous vehicle trials currently underway, mostly at the Level 3 or conditional autonomy stage. These trials are being led by Waymo, Google's self-driving vehicle arm, which recently announced the completion of three million miles of testing. In Australia, a number of automated vehicle trials are also underway. South Australia has been the first state to allow on-road trials of driverless vehicles and has pledged $5.6 million to a range of driverless services (Redrup 2017). With the support of the Western Australian State Government, the Royal Automobile Club is trialling a fully driverless, fully electric shuttle bus. Since launching in 2016, there have been 6,000 members of the public register to be a part of the trial (Royal Automobile Club 2017).

Table 1: Levels of autonomy (adopted from ICCT 2017a)

LEVEL	NAME	DESCRIPTION	COMMERCIALLY AVAILABLE	COMMERCIALLY AVAILABLE IN AUSTRALIA
0	No automation	Complete human control	Yes	Yes
1	Driver assistance	Vehicle can assist either steering or acceleration/deceleration	Yes	Yes
2	Partial automation	Vehicle can assist in both steering and acceleration/deceleration	Yes	Yes
3	Conditional automation	All tasks can usually be handled by the system, human takeover sometimes required	No	No
4	High automation	All tasks can be handled by the system without human intervention, but only in limited environments (e.g., college campus or dedicated zones)	No	No
5	Full automation	Automated system can handle all roadway conditions and environments	No	No

It is expected that Level 3 or conditional autonomy technologies will likely be available in commercial vehicles by 2018 and Nvidia, who are developing artificial intelligence for autonomous vehicles announced the introduction of a Level 4 enabling system by 2018 (NRMA 2017). This announcement will have significant impacts due to the partnership arrangements that NVIDIA have with a number of key global manufacturers. It has been further projected that Level 5 or fully autonomous vehicle capability where a driver is not required and vehicles will not have a steering wheel or accelerator, could be commercially available as early as 2025 (NRMA 2017).

As this technology becomes more readily available there are significant regulatory barriers both internationally and in Australia which need to be resolved (National Transport Commission 2017). Governments around the world, including in Australia, are beginning to consider what policy approaches are required to manage and support this trend (Government of South Australia 2017, Parliament of Australia 2017).

New business models

The last five years has seen the emergence of a range of new business models representing a significant shift towards MaaS. This trend will play a critical role in shaping the future of private transport. MaaS includes ride sourcing, ridesharing, and car-sharing. These services offer an increasingly convenient and cost-effective alternative to private vehicle ownership. When combined with autonomous technologies, the costs of these services will decline even further. The decline in vehicle ownership among younger people could indicate that the shift towards MaaS is already underway (McKinsey & Company 2016 and Clay 2014).

The formalised concept of car-sharing has existed for over a decade, and has traditionally been favoured by inner city residents that want access to a vehicle without the associated costs and space required by ownership. The car-sharing business model can be set up through a community organisation or a for-profit company, with the core principles being the same; a pool of vehicles is available for use by members of the organisation, with use charged by the hour. Monthly membership fees often also apply.

More recently, the development of ride sourcing and ridesharing has seen exponential growth around the world. As a subset of the sharing economy, this new business model uses technology to allocate underutilised resources more efficiently. Ride sourcing allows a passenger to hail a vehicle for immediate pick-up to be driven to their destination for a time and distance-based fee. The rise of Uber demonstrates the immediate capacity for large scale deployment of ride sourcing technology, with Apple and Google also investing. Ridesharing is a little different, where passengers can share a vehicle which could reduce vehicle costs, traffic congestion and emissions. UberPOOL is an example of a ridesharing service. Investment in shared mobility services, such as ridesharing and car-sharing, has so far been lower than investment in ride sourcing and the integration of ride sourcing with autonomy (ICCT 2017b).

In the future, full MaaS will provide total door-to-door mobility solutions allowing consumers to compare and utilise different modes of transport, including cycling and public transport, and access services through a single account and booking interface (Transport for NSW 2016).

Connected Car

Breakthroughs in artificial intelligence, better mapping, cheaper materials and the growth of online and mobile phone delivered services are creating more convenient and cheaper ways for people to move around. Changes in technology have already seen the role that smartphones can play in relation to real-time planning, open traffic data and social customer service (Deloitte University Press 2015).

NRMA has said that if “autonomous vehicles and smart infrastructure are the building blocks of a mobility future, the technology that makes the car ‘connected’ is the glue that binds them together” (NRMA 2017). We are already seeing considerable advances in the Connected Car, a vehicle which is IP-enabled and is able to interact with the Internet of Things to provide valuable services to drivers (Deloitte University Press 2015).

As technologies develop, vehicles will be outfitted with electronic control modules and sensors that will enable vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communications (Deloitte University Press 2015). Infrastructure will not limited to roads and traffic lights, but will also include other civil infrastructure such as buildings. The electronic control modules and sensors will be able to proactively suggest alternative travel routes to avoid hazards and call for assistance in the event of an accident; with vehicles soon being able to gain a precise-enough awareness of where they are in relation to other vehicles and potential hazards to take pre-emptive action to avoid accidents.

3. The future of private transport

3.1 Environmental and energy use impacts of emerging trends

The primary environmental impacts of private transport can be measured in greenhouse gas emissions and energy productivity. When considering greenhouse gas emissions, decarbonising the transport sector is essential to limiting global warming to less than 2°C above pre-industrial levels, and striving to limit warming to 1.5°C, in accordance with the Paris Agreement. Energy use also represents an important component of the environmental impact of future mobility. For example, if the total distance travelled by petrol or diesel vehicles increased or the energy efficiency of these vehicles decreased, this would result in increased energy use and greenhouse gas emissions. Even for electric vehicles, an increase in energy use could still have negative environmental impacts. Electric vehicles charged from the grid currently still produce some greenhouse gas emissions, and large increases in energy use from electric vehicles could have negative implications for the stability of the grid and our capacity to decarbonise electricity generation.

There are three factors that determine the level of greenhouse gas emissions and energy use from transport:

- **Fuel source:** Different fuel sources, for example, fossil fuels, electricity or hydrogen, have different implications for greenhouse gas emissions from transport.
- **Kilometres travelled:** Kilometres travelled has a direct impact on greenhouse gas emissions and energy use. For internal combustion engine vehicles, the distance travelled determines the amount of greenhouse gas emissions and energy use. Even for electric vehicles, the persistence of fossil fuels in the electricity generation mix means that total kilometres travelled is still linked to greenhouse gas emissions.
- **Mode:** The use of a private vehicle in comparison to public transport, or active transport, such as walking or riding a bike, also influences emissions and energy use.

Considered individually, the emerging trends of electrification, autonomy, and MaaS could have varying impacts on greenhouse gas emissions and energy use through their influence on fuel source, kilometres travelled and mode (Table 2).

Table 2: The impact of transport trends on the different factors that determine greenhouse gas emissions and energy use from transport

	ELECTRIFICATION	AUTONOMY	MOBILITY AS A SERVICE
FUEL SOURCE	↓	-	-
KMS	-	↑	?
MODE	-	?	?

Electrification

The literature suggests that electric vehicles are likely to have a positive impact on emissions and energy use in relation to private transport, based on their use of electricity as a fuel source (ICCT 2017b).

Fuel source: An electric vehicle charged from a renewable energy source emits no carbon emissions. Currently, consumers can access renewable electricity to charge electric vehicles through their own on-site generation from solar PV, or through procuring green energy through their electricity retailer. As the grid decarbonises in the future, zero emissions charging will be standard across all electric vehicles.

Kilometres travelled and mode: Electric vehicles as a future transport trend are unlikely to have an impact on total kilometres travelled or on transport mode shifts.

Autonomous technology

Autonomous vehicles will not of themselves deliver benefits for greenhouse gas emissions or energy use.

Fuel source: Autonomy in itself will not have an impact on fuel source; while it is more likely that autonomous vehicles will have an electric drivetrain rather than internal combustion, this is by no means guaranteed.

Kilometres travelled: Autonomous vehicles have the potential to cause an increase in kilometres travelled; as fully autonomous vehicles do not require a driver, people may be willing to travel longer distances as they will be able to focus on other tasks en route. Autonomous vehicles also enable zero occupant travel and the emergence of new user groups which could also result in greater total distances travelled. Autonomous vehicles could also use more energy per unit of distance travelled due to the potential for greater highway speeds (ICCT 2017b).

Mode: The impact of autonomous vehicles on transport mode is uncertain. As autonomous vehicles provide a reduction in driving stress and ability to focus on other tasks while en route this could encourage commuters to switch from public transport to private autonomous vehicles.

New business models

The impact of new business models on greenhouse gas emissions and energy use remains uncertain and may depend on the specific service considered.

Fuel source: New business models in themselves will not have a direct impact on fuel source.

Kilometres travelled: Ridesharing reduces total vehicle kilometres travelled by increasing the number of passengers in a vehicle. Carsharing could also reduce total kilometres travelled through facilitating a reduction in private vehicle ownership and encouraging mode shifting to public transport. For ridesourcing, the limited studies available suggest that ride sourcing could increase vehicle kilometres travelled resulting in higher congestion, energy use and emissions (ICCT 2017b).

Mode: Carsharing could facilitate a reduction in private vehicle ownership which could result in mode-shifting from private transport to public transport. The impact of ridesharing and ridesourcing on transport mode is less certain. If these services are sufficiently cheap, commuters may switch from active or public transport to ridesharing or ridesourcing, which could in turn increase energy use and emissions (ICCT 2017b).

Achieving the best environmental outcomes from public transport

Considering the range of potential outcomes from these trends in combination, there is growing consensus that the best environmental outcomes would be achieved through a future transport system that is electric, autonomous and shared.

Fulton et al (2017) found that a scenario with high take up of electrification and automation, but without sharing, results in a 40 per cent decrease in energy use in comparison to a BAU scenario. In contrast, a scenario with high take up of electrification, automation and sharing results in a roughly 70 per cent decrease in energy use in comparison to a BAU scenario. This scenario also provides the strongest greenhouse gas emissions reductions opportunities, however strong policy support will be required to achieve this outcome.

3.2 Policy support is needed to encourage positive outcomes

While there is growing consensus that electric, autonomous, shared mobility would provide the best outcomes for the environment in the future, it is unlikely that all of these three trends will become widespread without policy support. A number of different future scenarios are possible from a vehicle ownership and vehicle control perspective.

The development of electric, autonomous, shared transport systems could be impeded by a number of barriers. These include market failures, as well as technical, cultural and regulatory barriers. In order to direct society towards a future that produces positive environmental outcomes, governments will need to implement policies to address these barriers.

A key barrier to the uptake of shared and electric transport options is that road users only account for the private costs and benefits of taking a trip, and do not account for the costs to society as a whole, particularly in terms of congestion and air pollution (Grattan Institute 2017). This market failure means that without policy intervention, it is likely that road users will continue to favour private travel over shared mobility, as they will not appropriately account for the societal benefits of reduced congestion stemming from ridesharing. Similarly, road users may not choose to take up electric vehicles, as the societal cost of air pollution and greenhouse gas emissions is not factored into road users' decision making. Automation could further exacerbate the disparity between the private and societal costs and benefits of travel, as the cost of congestion to an individual road user will decline if there is no need to concentrate on operating the vehicle.

The adoption of shared transport options also faces psychological and cultural barriers (Pankratz et al 2017). Even where consumers are aware of societal and private benefits of choosing shared transport, cognitive biases could make them less likely to take up this option. Behavioural economists have found that people tend to overvalue losses and under value gains in their decision-making. People may also overvalue the status quo in comparison to potential alternatives. Combined with the cultural significance of owning and driving a vehicle, and a reluctance to share rides with strangers (Franckx 2017), these biases mean that people may be reluctant to forego their own vehicle for ridesharing options.

Achieving high uptake of electric vehicles with extended battery ranges also presents technical challenges, in terms of integration with the electricity grid. In a grid with an increased percentage of renewable energy, achieving the best outcomes for grid stability and the environment could require management of the timing and location of electric vehicle charging (National Grid 2017a).

Governments will need to implement policies to overcome these market failures, cultural barriers and technical challenges if the uptake of electric, autonomous and shared mobility is to occur. Without effective policies in place, the potential environmental benefits offered by future mobility may not be realised.

RECOMMENDATION FOR FURTHER RESEARCH:

- Further information and case studies on jurisdictions that are leading the world in the development of policies that will ensure positive environmental outcomes from the future of mobility.

4. The policy environment to enable this future

There are a range of policies that could help ensure that the future of mobility will provide the positive environmental outcomes outlined in Section 3. We have considered key transport trends and the policies required to deliver positive outcomes in the framework below.

Table 3: Transport trends versus policy

	ROAD PRICING	ROAD USE	INCENTIVES (RIDE-SHARE)	ENERGY SECTOR POLICY	ZERO EMISSIONS VEHICLE POLICY
FUEL SOURCE				X	X
KMS	X	X	X		
MODE	X	X			

There are also a number of overarching actions that would support the policies discussed in this section, including: better data collection, more flexible planning processes and mechanisms to revisit transport priorities as the sector shifts (Dutzik, Tomer, Baxandall and Puentes 2015).

We also recognise that while other policies may also be required, for example, to remove regulatory barriers preventing the roll out of automated vehicles, this report focuses on policies that have the potential to reduce greenhouse gas emissions and limit increases in energy use from the future private transport sector.

RECOMMENDATIONS FOR FURTHER RESEARCH:

- How to measure the uptake of electric, autonomous and shared transport options, and the impact of policy. This should include an evaluation of whether indicators for these changes can be recorded as part of the Australian Government's Smart Cities performance framework.
- A scenario assessment of the impact of different emerging technologies and business models on emissions from the private transport sector; including an analysis of opportunities to align uptake of these technologies with potential net zero emissions targets.

Road pricing

Road user charging could be used to limit potential increases in vehicle kilometres travelled with the advent of autonomous vehicles. Road user charging involves charging drivers based on the location, timing and volume of their road use (Productivity Commission 2014). This is in contrast to the current policy landscape in Australia, in which the price paid by road users, through registration fees and stamp duty, is fixed and does not account for the amount of travel. Under road user charging, the price paid to travel on a particular road should be reflective of the social cost of travelling on that road, including the driver's impact on congestion and air quality, as well as the cost of building and maintaining the road (Grattan Institute 2017). This policy could thereby incentivise road users to limit their trips or share their ride with others, resulting in less congestion and fewer total kilometres travelled.

One form of road user charging policy that has been successfully implemented internationally is a congestion charge. As with road user charging, congestion charging means that drivers pay more to use roads in particular areas at particular times of the day. London implemented congestion charges in 2003, under which motorists pay up to £11.50 (approximately AUD$20) to cross a boundary into the central city area. As a result, there has been an almost 25% decline in the number of vehicles entering central London since 2000 (Grattan Institute 2017). Singapore has had congestion charging in place since 1998, with prices for travelling within the city varying throughout the day to reduce peak hour congestion. Singapore has plans to extend the system to cover the entire island by 2020 (Grattan Institute 2017).

While these policies have the potential to reduce congestion, and therefore the energy used in private transport, there is also the potential for a perverse incentive for increased travel. Some commentators have pointed out that a higher price of transport in the inner city could result in businesses relocating to the outer suburbs to save on congestion charges (IET 2015). While this could reduce congestion, the longer travel distances could increase greenhouse gas emissions and energy use. An alternative approach could be to charge vehicles a set price for each kilometre travelled regardless of location (Isaac 2015). Examples of this policy already exist. For example, Oregon gives drivers the option to pay for the number of miles they travelled rather than paying a fuel tax, as a means to ensure sustainable funding of road infrastructure (Oregon Department of Transport 2017).

The effectiveness of these policies in limiting future increases in travel distance, or encouraging ridesharing has also not been ascertained. These policies act by placing a price on the amount and timing of travel, and thus rely on road users to be responsive to price when making travel decisions. However, more research is required into the level of pricing needed in order to encourage road users to switch to a shared mode of transport, such as public transport or ridesharing, especially in the context of increasingly autonomous travel. It is possible that direct road use regulations, or incentives directly designed to encourage ridesharing could be more effective in limiting an increase in road use from the uptake of autonomous vehicles.

RECOMMENDATION FOR FURTHER RESEARCH:

- The level of pricing needed in order to encourage road users to switch to a shared mode of transport, such as public transport or ridesharing, especially in the context of increasingly autonomous travel.

Road use regulations

Regulations that directly control road use could also be effective in limiting potential increases in vehicle kilometres travelled. These regulations could further support the uptake of ridesharing and limit unnecessary single or zero occupant travel by autonomous vehicles.

A number of governments already use prescriptive regulations to limit congestion. For example, Paris, Delhi and Mexico all dictate that vehicles can only be driven in the city on certain days based on the last digit of their number plate (Grattan Institute 2017). Jakarta had a policy that vehicles could not travel on major roads during peak periods unless they had three or more passengers (Grattan Institute 2017). Such regulations could be adapted or extended to be applicable in the context of autonomous transport. Some cities are already beginning to consider their options, with Helsinki planning to end private motor vehicle use by 2025 (Markham 2016), and Hamburg planning to ban vehicles from its city centre by 2034 (Paterson 2014). While such policies could be effective, ensuring sufficient public support could be challenging.

Direct incentives for car-sharing and ridesharing

Pricing and regulation can also be directly targeted at reducing vehicle ownership, in order to encourage the adoption of ridesharing and car-sharing (Isaac 2015). This could include options such as:

- higher sales taxes on private vehicles in comparison to shared vehicles;
- increased fees for public parking and taxes for private parking;
- dedicated parking spaces for shared vehicles;

- removal of minimum parking requirements in zoning laws;
- requirement for developers to include pick-up/drop-off locations; and
- increased proportion of lanes dedicated to high occupancy vehicles.

While these policies are unlikely to gain support in the immediate future, they could provide an important incentive to encourage the uptake of ridesharing as the mobility transformation progresses.

Planning for the integration of electric vehicle charging into the grid

As electric vehicle uptake increases, governments and energy market regulators will need to consider how best to encourage charging behaviour that limits strain on the grid.

Internationally, regulators have begun to consider this issue. For example, the UK's National Grid has examined the grid implications of the Government's recently announced policy to ban the sale of petrol and diesel vehicles by 2040 (National Grid 2017b). National Grid found that at this level of uptake, with smart charging that automatically responds to time of use pricing, peak demand from electric vehicle charging will be about 5 GW, or 8 per cent of the grid's current peak demand. In contrast, in a scenario where charging does occur during peak periods, the impact on demand is much higher, at around 30 GW or 50 per cent of current peak demand. This illustrates the need for governments and regulators to consider how to design policies to enable efficient charging.

In addition, the potential emissions benefits of electric vehicles will not be realised without policies to decarbonise the electricity sector. In order to meet the Paris Agreement's long term decarbonisation requirements, emissions from electricity need to reduce by 45-60 per cent on 2005 levels by 2030 (ClimateWorks Australia 2017b). In comparison to the current situation, this requires a substantial increase in renewable generation and decrease in fossil fuel generation that can only be delivered through effective electricity sector policy.

RECOMMENDATIONS FOR FURTHER RESEARCH:

- The potential for electric vehicles to act as distributed energy resources that export electricity to the grid, and the impact for the grid.
- The impact of different levels of grid electricity emission intensity, and uptake of distributed renewables, on private transport emissions.

Zero emission vehicle policy

International experience has demonstrated that policy can be critical in encouraging the uptake of electric vehicles. In comparison to our global peers, policy support for electric vehicles in Australia remains in its early stages. Australia does not currently have an overarching electric vehicle policy framework, which limits the capacity for a coordinated national approach.

One broad and comprehensive policy that could encourage the uptake of electric vehicles is the introduction of light vehicle CO_2 emissions standards. Australia is one of the few remaining developed countries without light vehicle CO_2 emissions standards in place, with standards covering over 80 per cent of the global automotive market (ICCT 2015b).

The introduction of a light vehicle CO_2 emissions standard would be the first step in decarbonising Australia's light vehicle sector. It would be expected that more stringent standards would be implemented in subsequent periods and low and zero emission vehicles will play a larger role in achieving these; particularly in the 2025 to 2030 timeframe, early adoption of electric vehicles will provide the lowest cost opportunity to meet these standards (ICCT 2017a).

5. Recommendations for further research

This report presents a high level overview of the trends shaping the future of private transport and the potential impact of these trends on greenhouse gas emissions and energy use. For Australia to ensure that the transformation of mobility has positive impacts for the environment, further research is required in a number of areas. A summary of potential areas of further research is outlined below:

- How the Australian context for the future of private transport differs from other international locations, including an investigation into the Australian policy context and geographical features of Australian cities.
- What are the likely environmental impacts of changes to transport congestion, usage and infrastructure in Australia by 2030?
- Further information and case studies on jurisdictions that are leading the world in the development of policies that will ensure positive environmental outcomes from the future of mobility.
- How to measure the uptake of electric, autonomous and shared transport options, and the impact of policy. This should include an evaluation of whether indicators for these changes can be recorded as part of the Australian Government's Smart Cities performance framework.
- A scenario assessment of the impact of different emerging technologies and business models on emissions from the private transport sector; including an analysis of opportunities to align uptake of these technologies with potential net zero emissions targets.
- The level of pricing needed in order to encourage road users to switch to a shared mode of transport, such as public transport or ridesharing, especially in the context of increasingly autonomous travel.
- The potential for electric vehicles to act as distributed energy resources that export electricity to the grid, and the impact for the grid.
- The impact of different levels of grid electricity emissions intensity, and uptake of distributed renewables, on private transport emissions.

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