ENGINEERS AUSTRALIA

Climate Change and Transport

Transport Australia Society Discussion Paper

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Purpose

This discussion paper is intended to give practical guidance to transport professionals on how they should incorporate consideration of climate change into their work. It should be seen as a statement of principles and objectives and does not replace or supersede engineers' obligations under other engineering guidelines and standards.

Scope

The discussion paper accepts the current scientific consensus on climate change. It is based on Federal and State government policies evidenced in documents such as the 2015 Climate 21 (Paris) Conference commitments (UNFCCC 2015) and Engineers Australia's Climate Change Policy as at July 2020. These both aim to limit global warming to no more than 1.5 degrees Celsius above pre-industrial levels. All parties to the Paris agreement aim to achieve carbon neutrality (i.e. net zero emissions) by 2050. They were also required to respond with nationally determined contribution (NDCs) for intermediate targets.

To date the Commonwealth response (NDC) to the Paris Agreement is that Australia has a target to reduce national emissions by 26-28% on 2005 levels by 2030. Emission targets for the transport sector in isolation are not specified, and it is assumed the overall target applies.

Austroads (2019) has identified that the Australian greenhouse gas (GHG) emissions reduction targets consistent with a global 1.5 °C trajectory are as follows:

- 2030: at least 50% reduction from 2018 levels
- 2050: 100% reduction from 2018 levels
- 2050+: Negative emissions

This paper contains advice on how engineers may contribute to meeting these agreements in their engineering practice on transport projects.

The paper is confined to discussion of the transport sector in Australia. This includes road, rail, sea and domestic air transport of passengers and freight. It does not consider broader social questions of climate change, population and actions for energy, land use, or other industries, other than how those issues might interact with transport. This paper assumes that current trends and government policies as at July 2020 will continue, and this assumption forms the basis of the comments. Given the urgency to implement climate change solutions, this paper focuses only on those feasible with current technologies.

Urgency

There is at present no policy on reducing transport Greenhouse Gas (GHG) emissions in Australia to meet the overall Paris target. Given the scale of Australia's overall GHG emissions caused by transport, significant reductions in transport GHG emissions will be required to meet the target.

Transport infrastructure has a long design life of up to a century and many vehicles remain serviceable for over 20 years. Greenhouse emissions such as carbon dioxide persist in the atmosphere for 300 years or more (NASA 2019). Achieving large scale reductions in transport emissions by 2050 will require changes in decision making in the short term.

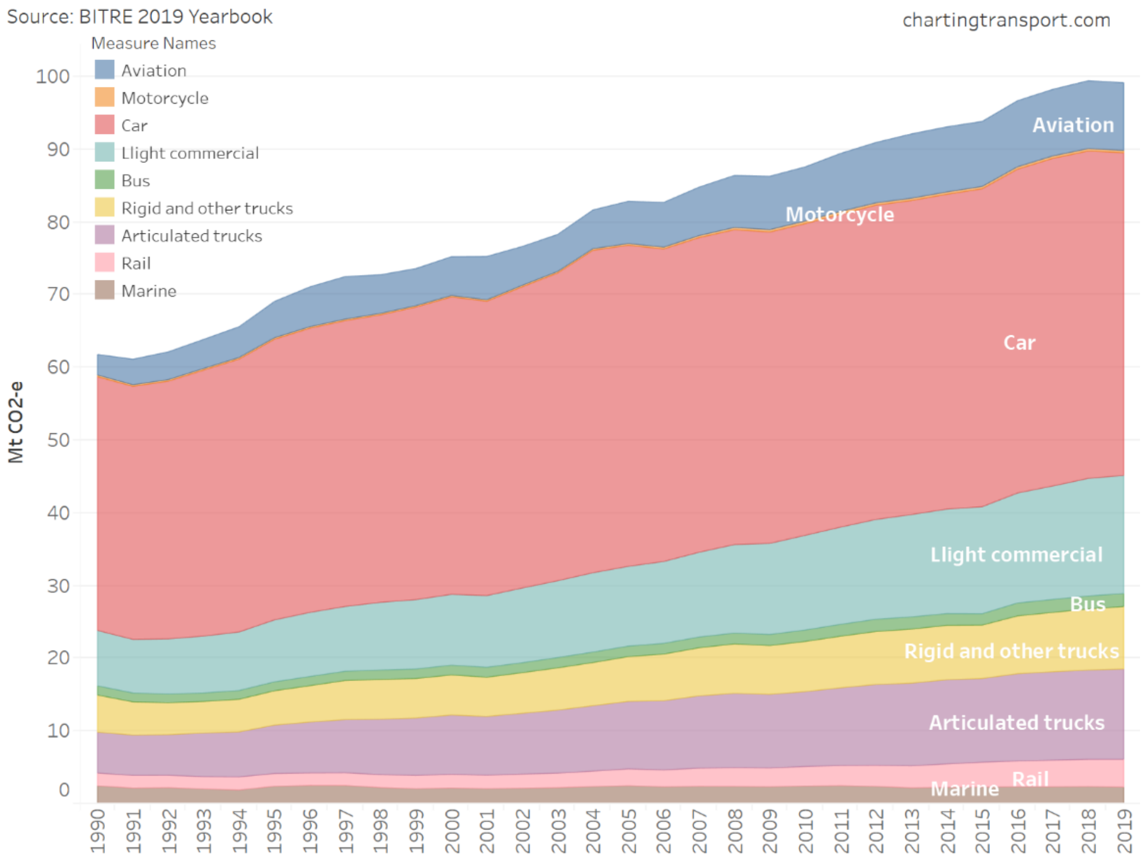
Context

It is estimated that Australia's total transport activity contributes over $122 billion annually to the economy (ABS 2018). Transport networks, whether they are road, rail, air or sea-based, enable the population to carry out everyday activities and the movement of freight from origin to destination. Passenger and freight travel on these networks are major emitters of greenhouse gases resulting in anthropogenic climate change.

The scale of emission reductions targeted by 2030 and 2050 require decarbonisation - a shift in vehicle technology from fossil fuels to electric vehicles powered from renewable sources (Austroads 2019). Complementary changes to transport networks, construction methods and operations will enable and support this change. Changes to technical processes that influence the nature of the Australian transport fleet and infrastructure need to occur before 2030 for the 2050 target to be achievable.

The transport sector is responsible for 100 Mt CO_2-e per annum, or 18% of the total greenhouse gases emitted in Australia, a share exceeded only by electricity and industrial production. In 2019 this rate had reduced by 1.0% with urban passenger and light commercial vehicles the fastest growing segment. Prior to this the trend had been for Australian transport GHG emissions to be increasing. Contributions by mode and their growth trend are shown in Figure 1.

Figure 1 Domestic non-electric transport emissions, Australia Source: (Charting Transport, 2019)



The Australian Government has committed to reducing its emissions by 26 to 28 percent from 2005 levels by 2030. Between 2005 and 2018 transport emissions grew by 23 percent. The transport sector faces an urgent challenge to establish how it contributes to this target and how to change our emission trends so that net zero by 2050 is possible. The Australian Government has established the performance monitoring program that tracks emissions and has a range of regulatory levers at their disposal, including vehicle design rules, infrastructure procurement standards, fuel quality standards and environmental legislation. State Governments regulate and manage most of the sector and have established many relevant mechanisms.

The engineering community is faced with considerable complex challenges and is tasked with directing best practice that is destined to impact future generations. The Australian vehicle fleet consists of 20 million cars, buses, trucks and trains. Decarbonising this fleet by 2050 will take a substantial effort and should start immediately. Decarbonising transport operations in the face of population growth, urbanisation and expanding transport networks will not only lead to reducing the impacts of climate change but also broader positive environmental, social and economic impacts.

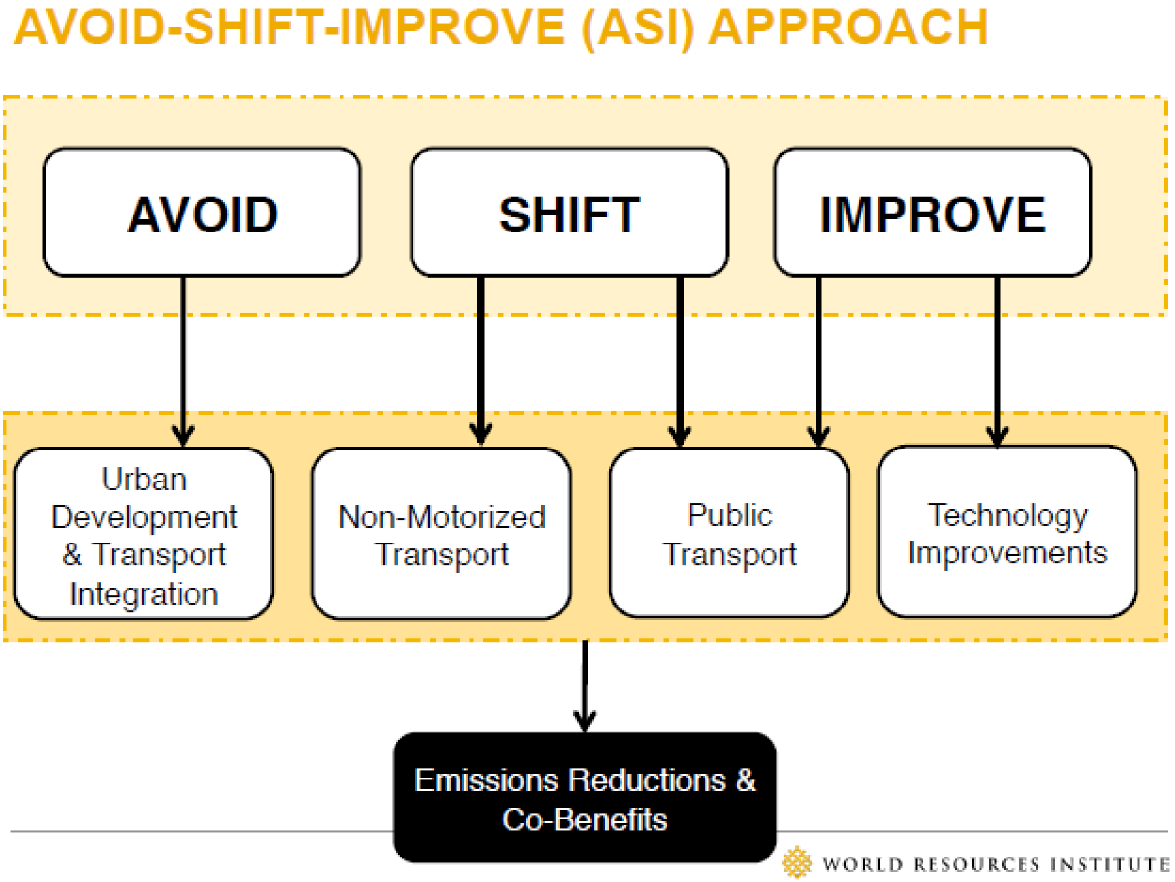
Australia's engineering community has a responsibility to develop pathways towards resilient transport networks that will operate effectively and contribute to achieving Australia's emission reduction targets.

Overall Framework

There is an urgent need to both reduce the contributions of transport towards the causes of climate change (mitigation) and to modify our transport networks to better cope with the climatic changes to which we are already committed (adaptation). These two objectives should be approached in the context of an overall framework, since there are many synergies between them.

The common framework of Avoid-Shift-Improve (SUTP 2019) is used in multiple countries to consider mitigation and adaptation options and is recommended for Australia. It is shown in Figure 2. This approach means seeking to avoid the need to travel, shift necessary travel to the most efficient means, and improve the efficiency of transport systems.

Figure 2 Avoid – Shift – Improve Approach (SUTP, 2019)



Practice recommendations will focus on passenger cars and light and heavy commercial vehicles as these are the major GHG emission sources from transport in Australia. The individual elements are discussed in following sections.

Mitigation

Avoiding the need to travel

"Avoid" refers to organising our cities to minimise the need for motorised travel in the first place. This includes changing the urban density and mix of land uses as well as organisation of how work and service opportunities are provided relative to residential locations. For example, having more dispersed local facilities, preferably co-located with public transport nodes, could reduce the length of many shopping and recreational trips so that many may become walkable or cycle

able. Global studies suggest around 25% of transport GHGs can be avoided by such strategies (Creutzig et al, 2015).

This approach needs to be implemented over the long term but has large benefits that compound. Our built form and urban planning rules determine much of our travel requirements and the preferred mode. For example, the common Australian practice of mandating minimum parking requirements acts to increase the cost of providing new dwellings while forcing capital investment to be devoted toward dedicated space for car storage. A market-oriented approach would enable developers and home builders to choose how much car parking to invest in and would encourage innovations to use parking facilities more efficiently.

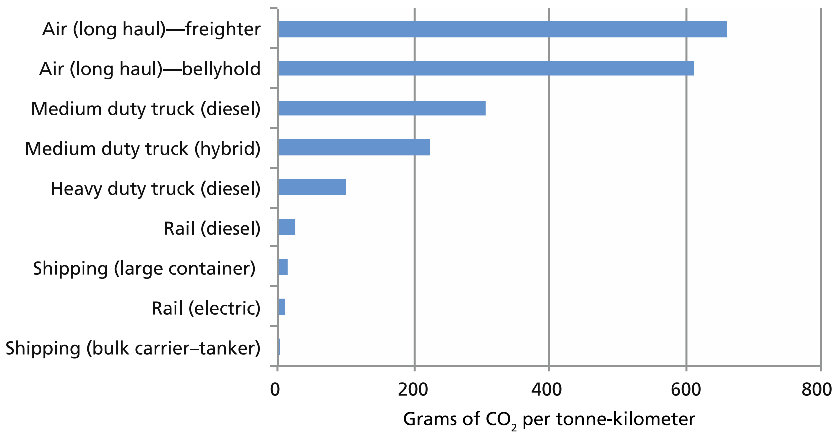
New technology and investment in other sectors can have substantial transport implications. For example, due to SARS CoV-2 much of the white-collar workforce was able to transition to Working From Home (WFH) thus avoiding commutes and dramatically reducing congestion. A policy of continued WFH, perhaps one or two days per week for those who can, would reduce congestion and enable our cities to invest in improving alternative modes rather than additional traffic lanes.

Strategic transport planning should prioritise demand management and more efficient use of the existing network prior to investigating road expansion projects that cater for additional vehicle flows. Research has established that the 'predict and provide' transport planning approach leads to induced traffic that erodes the stated benefits and works against efforts to reduce emissions over the medium and long term (Duranton and Turner 2011). Providing additional road capacity does not reduce network-wide traffic congestion. Network operations efficiency; active and public transport mode improvements; and demand management strategies including changes to urban form are required instead to improve overall mobility and reduce emissions.

Shifting from motor vehicles to low emission modes

Shifting seeks to improve the emission efficiency of individual trips. Fossil fueled private cars and freight trucks are the highest emission modes of land transport. Shifting passenger transport from cars to active and public transport can reduce energy used per trip by an order of magnitude. Shifting freight transport from road to rail or sea can achieve similar reductions, as Figure 3 demonstrates.

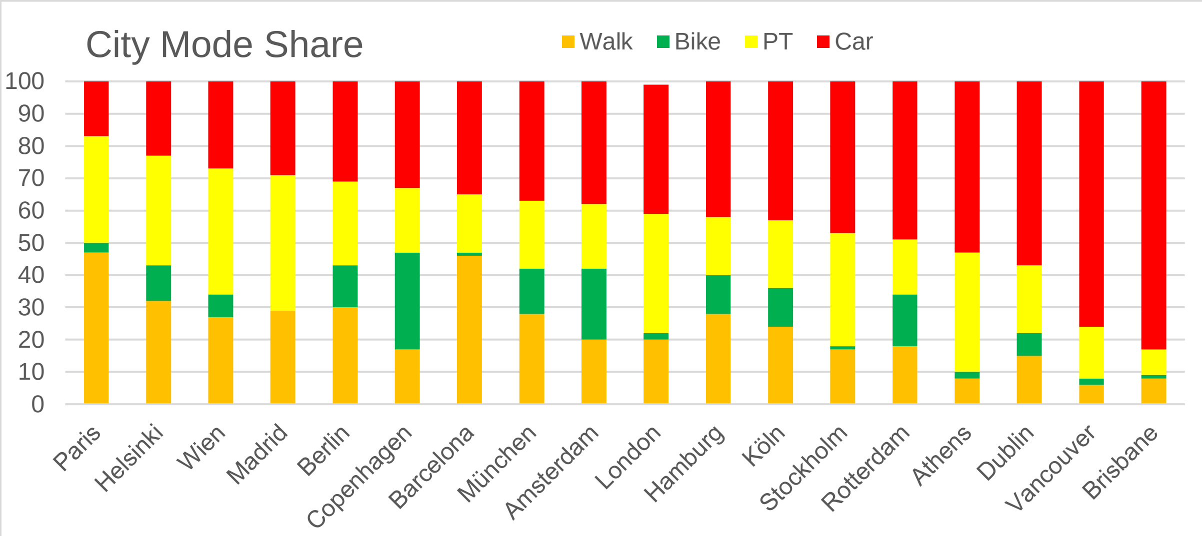
Figure 3 **Average Carbon Intensity of Freight Transport Modes (McKinnon, 2016)**



Cars, as well as being emissions-intensive, encourage dispersed settlement patterns and are also space-intensive. They deter zero emission active transport modes in their vicinity and work against many other city objectives such as improving amenity, livability and health. Roads are costly to provide, and their space consumption limits the potential for green space and makes higher density living or working less feasible.

Mode share data from other cities across the world shows a large variation in how urban travel occurs. This is not solely a function of urban density, with significant variation in active and public transport mode shares for cities of a given density. The walk, bike, public transport and car mode shares for a range of selected cities are shown in Figure 4. All are perceived to have a high standard of living, demonstrating that amenity and mobility need not be constrained by any reduction of cars.

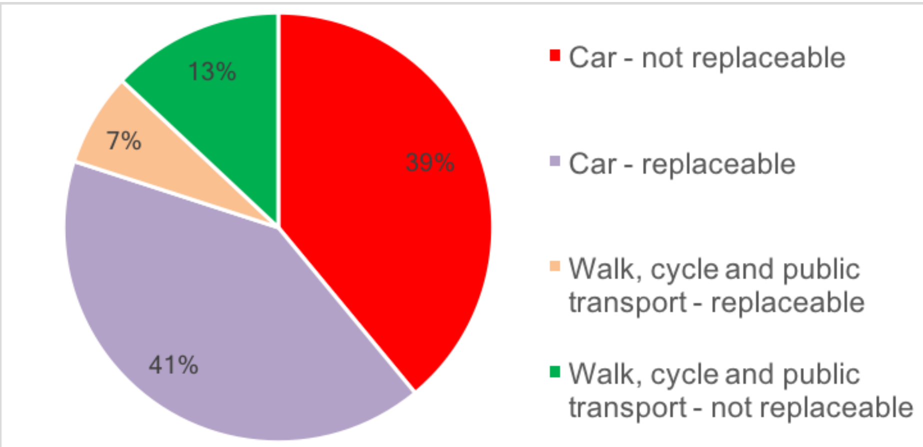
Figure 4 Transport mode shares for selected cities



Source: www.epomm.eu/tems/compare_cities.phtml

The results of a comprehensive analysis of the potential for travel behaviour change in Perth, based on detailed travel surveys and in-depth interviews, is shown in Figure 5. It concluded that up to half of car trips could be replaced by walking, cycling and public transport based on the existing urban form and infrastructure. Implementation of travel behaviour change programs have so far only achieved about one third of this potential, but that is a substantial change in the short term without infrastructure upgrade costs.

Figure 5 Perth potential travel behaviour change (Socialdata Australia, 2000)



The rapid evolution of micromobility over recent years provides another space and energy efficient mode. Low-powered electric bikes and scooters, speed limited to 25km/h can extend the catchment of public transport nodes and provide convenient fast access to local destinations in urban areas. Improved provision of separated paths for bikes and micromobility in our urban areas can overcome the perceived safety and convenience barriers that research has shown are the principal constraint on higher mode shares for walking and cycling.

The traditional approach to space allocation in Australian streets has over-catered for cars and car-parking at the expense of safety and connectivity for active transport modes. There is a large opportunity to implement traffic and access management improvements that shift urban street space allocation toward modes that are more space and energy efficient. For example, kerbsides could be used for protected bike/micro-mobility lanes, expanded footpaths and pick-up drop-off zones for the increase in e-commerce and shared services. Instead most of our kerbside is gifted for car storage despite most drivers having a low perceived value of parking and being unwilling to pay in most circumstances. The recent experience with SARS CoV-2 demonstrated that active travel is perceived as essential in local areas, but street design and traffic levels are a major obstacle to its growth.

The transport network is valuable land and receives considerable government investment, so the way it is priced and funded is an important consideration. Although the existing regime of Commonwealth fuel excise and state registration fees has generated substantial revenue, opportunities now exist to reform the system and more directly link charges with road use. A road price that is charged based on distance travelled or that increases in capital cities or when roads are congested could reduce congestion and emissions, thus delivering both economic and greenhouse benefits. The expected uptake of electric vehicles that pay no fuel excise provides an opportunity to introduce road pricing now.

Many climate change initiatives in the transport sector also have a range of co-benefits such as air quality, congestion, safety, physical activity, energy security and cost of living improvements. A more rapid advance toward zero net emissions is also an investment in better cities and better quality of life.

Improving the efficiency of transport network operations

Traffic Engineering has long been focused on improving efficiency and safety of vehicle operations. These should continue but GHG emissions should be added as a key performance indicator. Although like efficiency, this should emphasise people rather than vehicle throughput and prioritise improving the relative Level of Service (LOS) afforded to the most energy and space efficient modes, not necessarily cars. This will require changes to data gathering and network control systems.

Updates are also required to Australian signal control systems such as SCATS and STREAMs to enable more sophisticated forms of public transport priority as is standard on European and Asian systems. In high pedestrian volume areas and on principal bike routes, the number of active mode users and their delays should be measured and included in optimization algorithms. These systems need to be (re) focused to minimise person delay rather than vehicle delay. In urban areas active transport modes have amenity and human health benefits that need to be considered in parallel with travel costs.

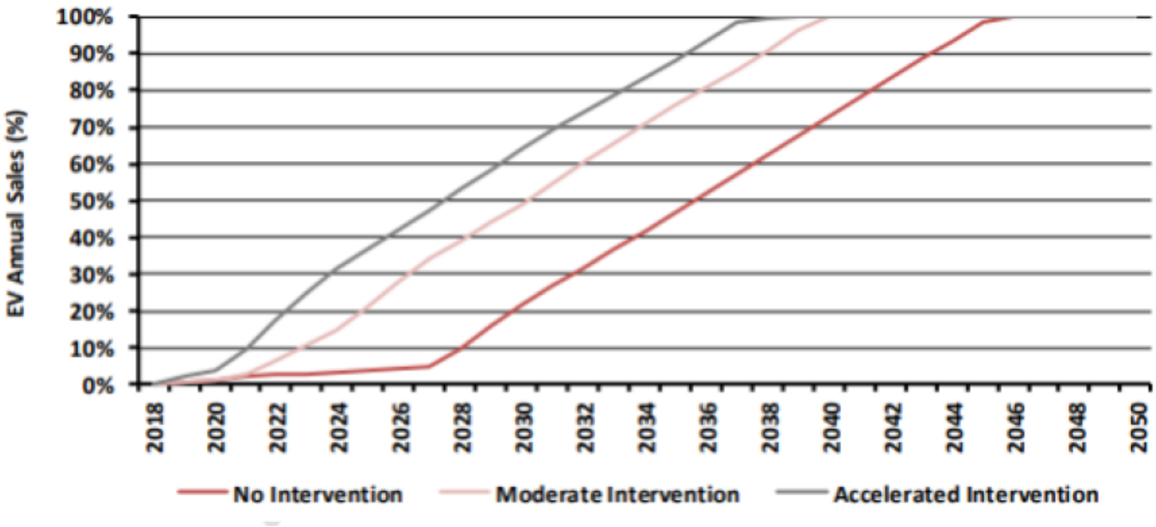
Improving the efficiency of vehicles and fuel sources

At present 70-80% of passenger travel is by private motor vehicles in Australian cities. With changes in priority and promotion of active and public transport from now until 2050 it should be possible to increase their mode shares toward 50%, still well short of any goal to achieve net zero emissions. “Avoid” and “Shift” are necessary and desirable, but insufficient to meet transport emission goals in Australia.

Fortunately for the light vehicle sector, a technology solution is already advanced and entering large scale production. Electric Vehicle (EV) price parity with Internal Combustion Engine (ICE) vehicles is expected to occur this decade (JP Morgan 2018). EV drivetrains are inherently more efficient than ICE drivetrains. Even where the power supply is from fossil fuels, EVs have lower total emissions than ICE vehicles (Austroads 2019). When charged using renewably generated electricity, EVs are effectively zero carbon emissions during operation. Investment in EV development is such that they now provide superior performance with reduced maintenance requirements compared with ICE vehicles. EVs have lower operating costs as domestic electricity charges are well below the price of refined petrol and diesel for an equivalent driving range. The electricity grid is ubiquitous across Australia, so the provision of safe, convenient and affordable electricity charging facilities is underway and can roll out quickly. Replacing imported liquid fuels with domestic electricity will also benefit the current account balance.

The challenges for EVs in the near term are their higher upfront cost and range anxiety. EV range is already acceptable for urban use and this issue will diminish with technical advancements and deployment of a wider network of recharging points. Either market or regulatory mechanisms are required to increase EV uptake rates and grow our familiarity with the technology in advance of mass uptake (Austroads 2019). Most OECD countries have implemented several mechanisms, with Norway already achieving about half of all new vehicle sales being EVs. By the early 2030s, it is possible that ICE vehicles will be effectively eliminated from the new vehicle fleet, represented by the Accelerated Intervention scenario in Figure 6 below. A range of countries, including the United Kingdom, are already implementing legislation to this effect. EV uptake can be supported in a cost neutral manner through: purchase incentives combined with a road price; modifications to existing government charges and vehicle tax subsidies; and by aligning fuel quality and vehicle emission standards with best practice.

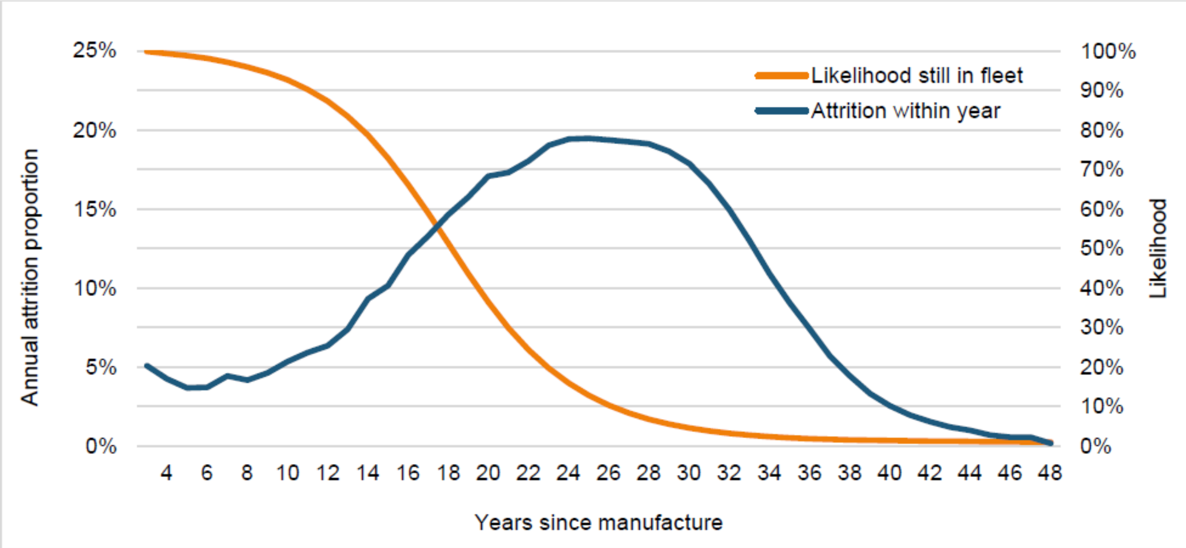
Figure 6 Electric Vehicle uptake scenarios for Australia, % of new light vehicle sales



Source: Energia (2018)

Even with all new vehicle sales being EVs by 2035, there will remain a substantial legacy of ICE vehicles beyond 2050 if the market is left to its own devices, as shown in Figure 7 below. Mechanisms will be required to encourage or force the retirement of ICE vehicles over time through scrappage schemes or more stringent fuel quality and emission requirements, alongside effective waste programs that recycle most vehicle components. By 2050 any remaining ICE vehicles should be registered as collector cars for historical and enthusiast use only.

Figure 7 Vehicle attrition in Australia



Source: Austroads *(2020)*

Electric power is also being applied to other vehicle types. Electric trucks and courier vehicles are now entering the market. Electric buses are entering service in China and Europe and should be the basis of future bus fleet purchases in Australia. They have higher capital cost but lower operating cost. Electricity is already commonly used for high volume rail freight and is emerging for other transport tasks such as electric planes for short haul flights.

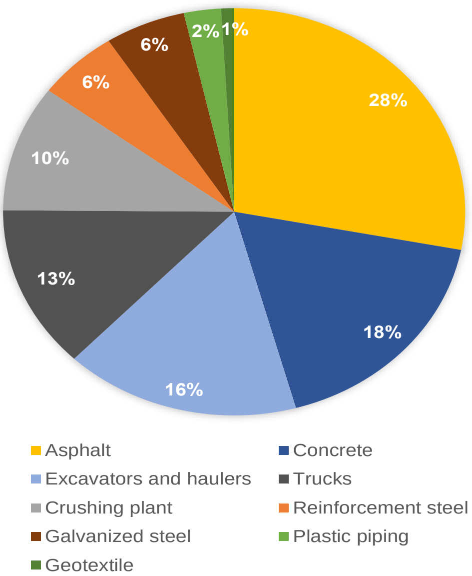
Other low emission technologies have been proposed as alternatives to ICE vehicles but are not considered reliable and cost effective for large scale implementation in urban commuting fleets. The feasibility of using hydrogen powered fuel cell electric vehicles (FCEVs) is not proven within the timeframe required for large scale adoption in urban commuting to meet 2030 and 2050 targets (Lambert, 2020, Austroads 2020).

Improving the efficiency of infrastructure construction

Construction of transport infrastructure involves the use of large quantities of engineered materials. These embody a large amount of energy required for their extraction, processing, placement and end-of-life disposal. Recent Australian data is lacking. Globally the construction sector is estimated to cause up to 25% of industrial emissions. Production of steel, cement and asphalt are especially emission intensive. Adoption of best practice as per Figure 8 could halve road-construction GHG emissions. (Karlsson 2020).

Figure 8 Estimated GHG emissions from a Swedish road project, Karlsson, 2020.

All planning and asset management decisions regarding transport networks should include consideration of whole-of-life emissions. Where possible, the lowest emission option should be preferred.



- Planning and design of infrastructure and services should estimate the amount of emissions for each option in construction and operation and prefer the least emitting;
- Modify and reuse existing infrastructure or recycle materials from replaced assets, in preference to demolition of existing assets and/or new materials.
- Substitute long-life (e.g. stone), recycled (e.g. tyre rubber) or renewable (e.g. plant-based) materials for disposable or fossil fuel-based materials (e.g. plastics).
- Design infrastructure with high embodied energy for long service life to minimise waste.
- Adopt a policy of no net increase in emissions in new construction. This may be achieved by means such as revegetation, renewable power and purchase of carbon offsets or other incentives.

Freight transport

Long distance travel by air, sea or road, especially for freight, requires the storage of large amounts of energy with the lowest weight and space requirements feasible. This is likely to limit the usefulness of battery powered EVs paired with renewably generated electricity.

Aviation remains a major unsolved issue with synthetic fuel from carbon-dioxide capture being adopted in Switzerland. Biofuels, primarily biodiesel and bio-based jet fuels, play a key role in the decarbonisation of long-haul transport modes, complementing measures aimed at reducing freight demand and improving energy efficiency of operations. The International Energy Agency (IEA) estimates biofuels will provide some 40% of air transport fuel and 30% of bunker fuel for shipping by 2060. The IEA defines advanced biofuels as sustainable fuels produced from non-food crop feedstocks, which can deliver significant life-cycle emissions savings compared with fossil fuels, and which do not directly compete with food and feed crops for agricultural land or cause adverse sustainability impacts.

A National Hydrogen Strategy (http://www.coagenergycouncil.gov.au/publications/national-hydrogen-strategy) explores avenues for Australia to utilise hydrogen across many sectors of the economy, possibly including transport. Hydrogen could power freight transport, especially over long distances, when it overcomes technology and cost-effectiveness barriers. This may become feasible when solar and wind generation provide over 100% of electricity demand. Then, through electrolysis of water, hydrogen becomes a cost-effective means to store excess electricity and make it available for non-grid uses. Hydrogen is not favoured at present due to major cost differences from the need to produce and safely store hydrogen, whereas electricity is readily available (Whitehead et al, 2020).

Adaptation

The impact of climate change on the Australian landscape, and society will require adaptation in the way engineers build and operate transport networks. Engineers will need to deliver infrastructure able to operate reliably in foreseeable climate conditions. Adapting approaches to mode choice and project scoping will reduce infrastructure impacts. Longer lasting infrastructure will result in less waste and material use. Demand management will enable the amount of new construction to be minimised.

Creating Resilient Networks

In the past century average Australian land temperatures have increased by 1 degree Celsius and a further 0.5 degrees Celsius or more is expected (CSIRO 2019). There will be a corresponding increase in design values of climatic factors such as temperature and rainfall intensity. There will be increased frequency or severity of extreme events such as heatwaves, bushfires, flooding, sea-level rise and storm surges. These must be considered in planning, design, maintenance and operation.

Adaptation to climate change in transport infrastructure should be planned for the life of the infrastructure. If we expect a bridge or railroad to last 100 years, then it should be designed to operate safely in the climate range forecast in 100 years' time. The following issues are foreseeable and should be considered in planning, design and construction of new infrastructure, and maintenance and operation of existing infrastructure:

- Allow for higher average temperatures, and a larger range of extremes in design, including thermal expansion, heat degradation, and passenger comfort.
- Maintain or improve micro-climate in urban works by planting trees for shading and providing breeze corridors to reduce the urban heat island effect and improve liveability.
- Allow for sea-level rise and storm surge increases in coastal transport links
- Plan for a wider range of extreme events such as bushfires, cyclones and floods.

Creating less impacting infrastructure

Transport infrastructure is a significant contributor to GHG emissions. Transport networks require large amounts of energy to operate, occupy large amounts of physical space, and contribute to urban heat island effects. There is a need to adapt infrastructure planning and design processes and delivery capability to focus on infrastructure that is the most efficient choice of mode, scale and location. A focus on improving rather than degrading amenity through projects will improve active transport use.

Some of these changes will require amendment to project planning and assessment processes. For example, current high discount rates for economic assessment discourage long term investment, which results in multiple cycles of wasteful reconstruction, and reinforces reliance on the inefficient status quo. Other changes require research to better understand risks and opportunities. A stronger skill-base is required in climate science and urban habitat in planning and design teams.

Engineering Practice Recommendations

This chapter presents a range of proposed recommendations for engineering practitioners. These recommendations are intended to guide engineering professionals who may be engaged in the planning, design, construction and operation of transport systems and infrastructure. They are intended to identify good engineering practice in respect of climate change.

Short Term Priorities

In order to meet 2050 emission reduction targets, action is required between now and 2030 for the following transport network aspects:

- Regulatory and financial incentives to encourage a market shift from ICEs to EVs.
- Develop mixed land-use transport plans for urban areas that reduce the need for car travel.
- Prioritise delivery of active and public transport projects over road capacity in urban areas.
- Update traffic control systems to give priority to public transport and maximise person flow.
- Develop and implement travel demand management strategies for all Australian cities.

Other priorities may exist in policies for individual states and territories.

General principles for engineering practitioners

The following are practical actions that engineers can take in delivering their work to achieve better outcomes for climate change with transport projects.

- Engineers should act to reduce or at least not increase anthropogenic greenhouse gas emissions in all transport projects. The use of offsets or compensatory works may be required.
- Engineers should identify and implement project solutions that have the least whole of life greenhouse emissions, within the limits of project budgets, and without compromising their duties of care for safety and environmental sustainability.
- Minimising greenhouse gas emissions should be seen as an extension of the duty of care that engineers hold with regard to environmental sustainability and community health and safety.

Planning and design

- Transport planning should include demand management, land-use and other “non-build” options.
- Demand forecasting models should be based on up to date behavioural data and sensitive to factors including induced demand, behaviour change, and technological change.
- Infrastructure design should maximise vegetated area and enhance local micro-climate.

Infrastructure construction

- Construction management should minimise construction emissions through the choice of material type, sources, haulage distances, stockpiling and processing operations
- Preference should be given to the use of recycled materials and long-life new materials.

Transport network operations

- Greenhouse gas emissions from transport network operations should be measured and reported.
- Transport network operations should be managed to minimise greenhouse gas emissions.
- Urban transport network management should focus on maximising person flow and maintaining accessibility rather than reducing short term congestion.

Personal work practices

- Engineers should act to avoid or minimise greenhouse gas emissions in their work through their choices of workplace, work travel modes, use of telecommuting and videoconferences.
- Engineers should choose the zero emission or lowest emission transport mode or vehicle able to be afforded that has the safety and performance characteristics required for the role.

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