

## Rapid reductions in passenger transport embodied and operational emissions

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Rapid decarbonisation is required to mitigate global warming. The World Meteorological Organisation recently announced that “there is a 20% chance that [the annual mean global temperature] will exceed 1.5°C in at least one year” in the coming five year period [1].

A carbon budget for Australia can be calculated in two ways – the first by using our current share of annual emissions as an indication of the CO<sub>2</sub> that can be emitted before we reach net zero emissions, and the second using a more equitable framework, where per capita emissions for all people are equal. According to Diesendorf and Angove (and excluding other greenhouse gas emissions), the first method leaves 18 years to reach net zero emissions, and the second, more equitable method would mean we have 6 years to reach net zero emissions [2]. Apart from some difficult sectors, such as aviation and some industrial activities, there is likely no technical impediment to rapidly reaching net zero emissions whilst ensuring a good quality of life for all Australians. The impediments are rather social and political. Indeed, it is likely easier to ensure we live comfortably in a carbon constrained world, rather than learning to live within a warmer, more dangerous, world.

The costs of solar photovoltaics and wind have fallen to a level where they are already competitive with new build fossil-fuel plants, and are expected to be competitive with the fuel, operational and maintenance costs of legacy plants worldwide within a few short years [3]. Solutions for rapid decarbonisation in the building sector have existed for a long time, and with appropriate support could be quickly implemented in the mainstream [4]. Stationary energy excluding electricity can largely be electrified and so decarbonised [5]. Fugitive emissions vanish as methane mining and consumption are phased out in favour of electrification. Transport is one of the sectors in which emissions have continued to rise, due in part to consumer preference for sports utility vehicles (SUVs) [6].

Passenger vehicles seem convenient to owners and passengers, but have many drawbacks, including poor local air quality (this is true even for electric vehicles [7]), large requirements for space [8] and consequent high rates of congestion, increased fatality and injuries for pedestrians and cyclists [9], relatively high embodied emissions [10], poor energy productivity (just 0.5% of the energy consumed by a car is used to move the driver [11]), the popularity of SUVs have led to an increase in emissions (negating gains in other sectors) [6], poor understanding of the costs to own and maintain a vehicle which prevents mode shifting to public and active transport [12], and induced demand from large-scale motorways [13] [14].

Transitioning to an electric vehicle fleet will lock in many of these problems. It is also likely to take quite a long time – even the most optimistic estimates put this figure at 6 years to reach 100% new electric vehicles [15], and it will take longer for the residual ICE vehicles to be retired (although increasing liquid fuel prices and maintenance prices could push these out quite soon). In the most optimistic of the 2020 CSIRO *Projections for small-scale embedded technologies* EV scenarios, EVs are projected to make up 100% of the road transport fleet in 2040. The most optimistic scenario sees the EV sales share in 2050 as being just 30% [16]. Granular technologies, such as electric bicycles (or rooftop solar) can diffuse more quickly than their large-scale counterparts and so drive rapid decarbonisation [17].

Transitioning the current Australian fleet of passenger vehicles (14.3 million vehicles) now to a fleet of Nissan Leafs would consume 139 Mt of CO<sub>2</sub> from vehicle and battery manufacture alone [10]. This does not include the shipping and road transport emissions to bring them to the new owners, nor the increased embodied emissions for larger cars or SUV EVs.

In contrast, a rapid transition to electric bicycles (EBs) has many advantages. Local air pollution from tyre particles and brake pad degradation are much lower than for passenger EVs, EBs require significantly less space than passenger vehicles, they create little (if any) noise pollution [18], they provide increased opportunities for incidental exercise for an otherwise sedentary population – with consequent improvements in public health outcomes [19] [20], EBs can require less effort to ride than conventional bicycles [18], there are accessible and safe options available for the young and the elderly to travel independently, costs for EBs would be lower for the populace when compared with EVs [18], and finally EBs have much lower embodied and operational emissions per kilometre travelled, as shown in Table 1 (for the UK) [21].

**Table 1: Lifecycle emissions [g/km] for different modes of personal transport [21]**

	Lifecycle CO <sub>2</sub> emissions g/km
e-bike	22
Battery electric car – Nissan Leaf	104
Hybrid car – Toyota Prius	168
Petrol car – EU average	258

Disadvantages do include poor protection from inclement weather [22], relatively poor current security options, and the occasional need for bathing/changing facilities at the destination.

Without dedicated infrastructure, such as physically separated cycle paths, people (and in particular, women and children [23]) are reluctant to switch to cycling. A survey of Copenhagen citizens found 56% of residents cycle because it is quick, whereas just 1% cycle for environmental reasons [24]. The COVID-19 pandemic has highlighted the need for open space for exercise, and for travel options that ensure social distancing is possible whilst limiting GHG emissions. Many cities globally have fast-tracked pop-up cycleways, which have allowed millions more trips to take place via bicycle. These changes in public infrastructure have proven to be extremely popular. For example, a survey of residents of London, Birmingham, Manchester, Leeds, and Glasgow found that 81% of residents were in favour of measures to reduce car emissions and use [25]. Paris recently re-elected Mayor Anne Hidalgo, who has been a champion for mode changes and increased green space within the city [26]. Ireland has announced that 10% of the transport budget will be spent on cycling, and 10% on walking infrastructure [27].

We compare the embodied and operational emissions from a rapid Australian transition from ICE passenger vehicles to electric bicycles for a range of scenarios (supported by a rapid roll-out of shared EVs) and EVs for those drivers who by necessity travel longer distances, compared with the most optimistic and pessimistic scenarios for total passenger fleet replacement to EVs.

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