Charge!

Can Charging Users Reduce Transport Carbon Emissions?

This paper has been peer reviewed

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INTRODUCTION

In the war to reduce carbon emissions from the transport sector in New Zealand, and in Auckland in particular, is the use of targeted fuel taxes / road pricing / congestion charging a viable, effective and efficient tool?

Can more charges be fair and equitable? Are they simply another revenue source to fund transport system improvements, or can we target the highest carbon emitters and potentially benefit low emitters? Do charges really change behaviours? What examples of effective (and ineffective) charging regimes have been implemented overseas that we may learn from, what is our largest city contemplating and will this be effective in reducing carbon emissions?

This paper seeks to answer these questions and to propose ideas that could have real impact on the transport sector carbon emissions.

BACKGROUND

NZ Transport Sector Trends

More CO_2. The NZ road transport sector was responsible for emitting about 15 million tonnes of carbon dioxide equivalent (CO_2-e) in 2019, nearly twice the 1990 figure. (Ministry for the Environment 2021).

More Driving. Despite some improvement in vehicle efficiency, carbon emissions from transport are increasing in NZ. Total vehicle kilometres travelled in NZ increased by 33% between 2001 and 2019, despite five years without increase following the 2009 global financial crisis (Figure 1). While growth in light passenger vehicles has been only 22%, the highest increases were in bus (+122%) and light commercial (+84%). The growth in heavy truck kilometres has also been higher than the average at 44%. The faster growth in larger-engine vehicles may well be offsetting any increased efficiency of the fleet.

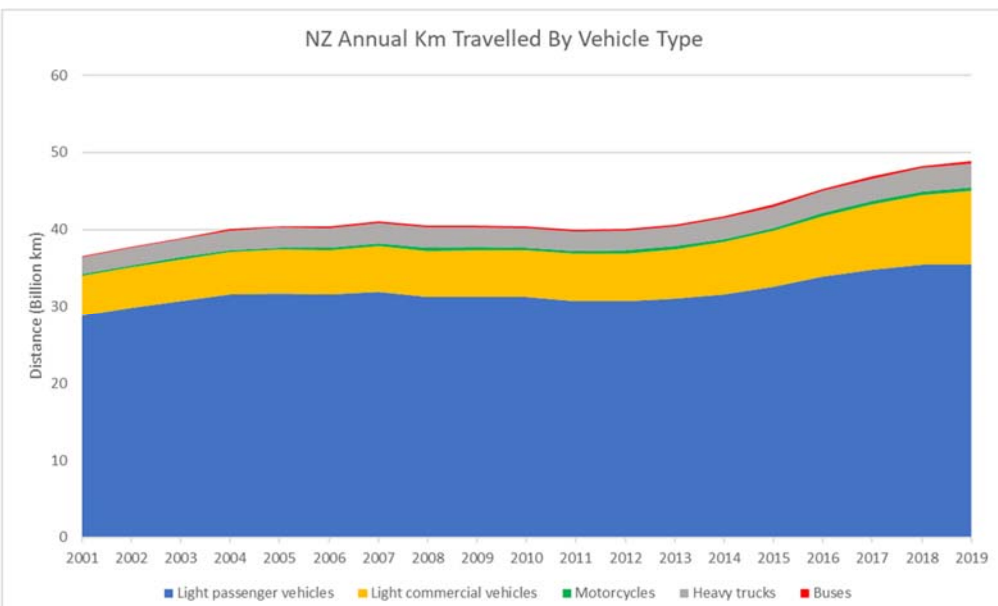

Figure 1 Vehicle Kilometres travelled by vehicle type NZ 2001-2019 (Ministry of Transport 2021)

More Diesels. Of interest in considering carbon dioxide (CO_2) emissions, the distance driven by diesel vehicles has doubled in this period, while petrol vehicles km has increased by only 16% (Figure 2). Generally, diesel vehicles consume less fuel and emit less CO_2 per km than equivalent petrol engine vehicles.

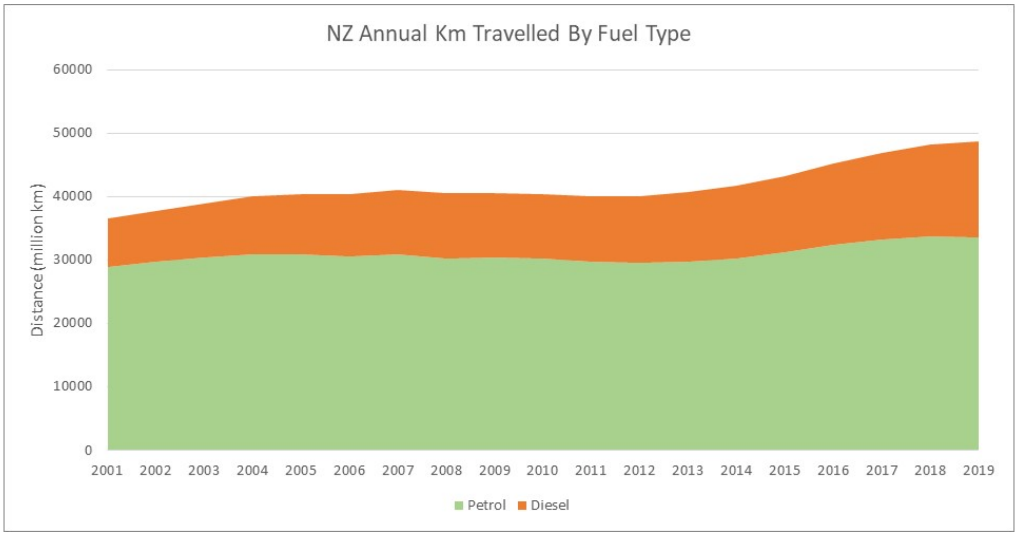

Figure 2 Vehicle Kilometres travelled by fuel type NZ 2001-2019 (Ministry of Transport 2021)

Bigger Engines. The potential CO_2 emission benefits arising from the increase in the use of diesel engine vehicles is, however, likely offset by a dramatic increase in the proportion of distance travelled by larger engine vehicles (Figure 3). The distance travelled by vehicles with engines 2000-3000cc increased by 75% between 2001 and 2018 and the increase in over 3000cc mileage was 34%, while vehicles with engines smaller than 2000cc showed very small growth (7%) over this period.

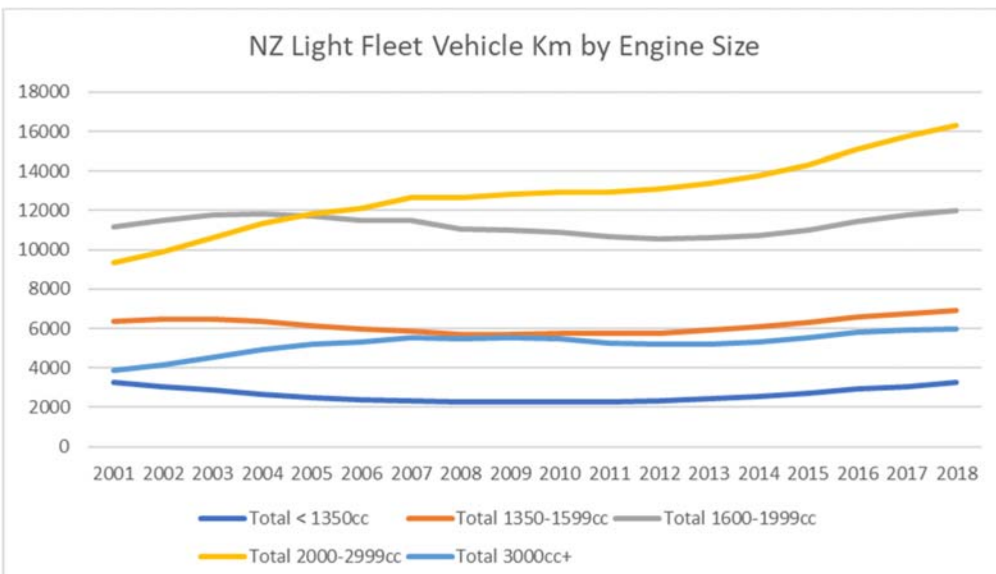

Figure 3 Light Fleet Vehicle Kilometres travelled by engine size NZ 2001-2019 (Ministry of Transport 2021)

Analysis of new vehicles available in the market in 2021 (UK Department for Transport 2021) shows a wide range of fuel consumption and CO_2 emissions, from nil for all electric vehicles up to 384 g/km for the 6.6 litre Rolls Royce Ghost. Figure 4 CO_2 emissions from the 2020 UK vehicle model rangeFigure 4 shows the range of CO_2 emissions from the 292 car models currently available in the UK, with examples of the vehicle models within emission bands shown.

The models shown in red text are among the highest selling models in New Zealand, with the Ford Ranger and Toyota Hilux being the biggest selling models over the last three years (2018-2020) (Motor Industry Association NZ) and also being well on the high side of average in terms of CO_2 emissions per km. While not as common, there are a substantial number of the higher emitting vehicles on New Zealand roads, including Toyota Landcruiser and Range Rover.

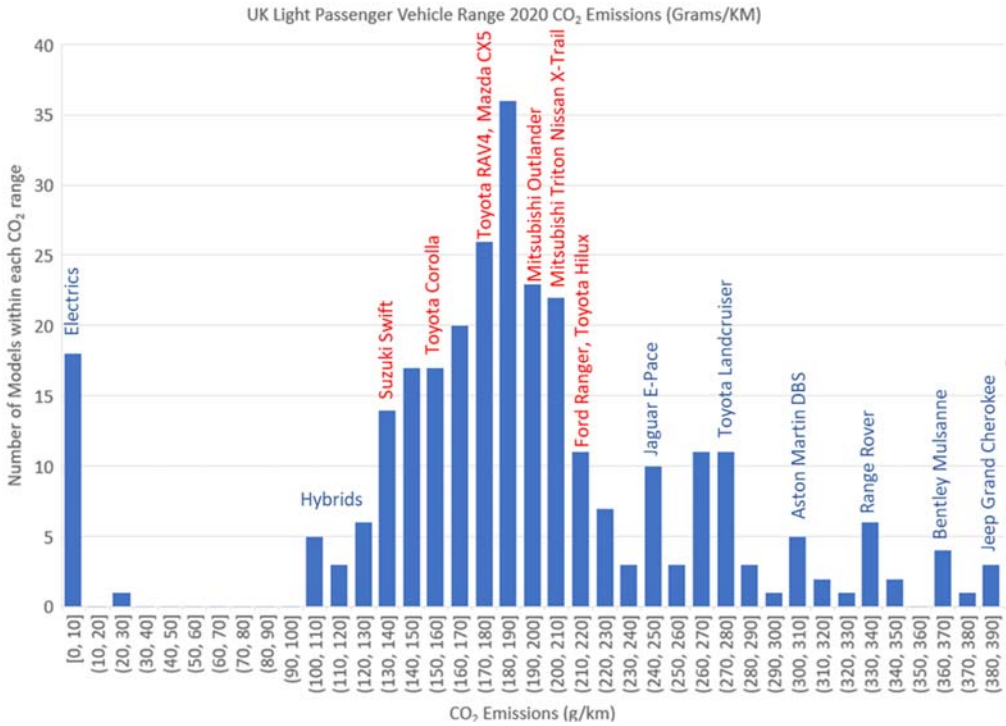

Figure 4 CO_2 emissions from the 2020 UK vehicle model range (UK Department for Transport 2020)

Auckland

Auckland Council's greenhouse gas emissions inventory found that in 2016, road transport emissions contributed 37.6% of total greenhouse gas emissions in Auckland, as a product of fuel consumption and vehicle kilometres travelled (VKT). (Auckland Council 2019).

As shown on Figure 5, Auckland accounts for the largest share of NZ vehicle travel of any region (32%), and the Auckland region has also seen the highest increase in travel (44%) since 2001 of any region.

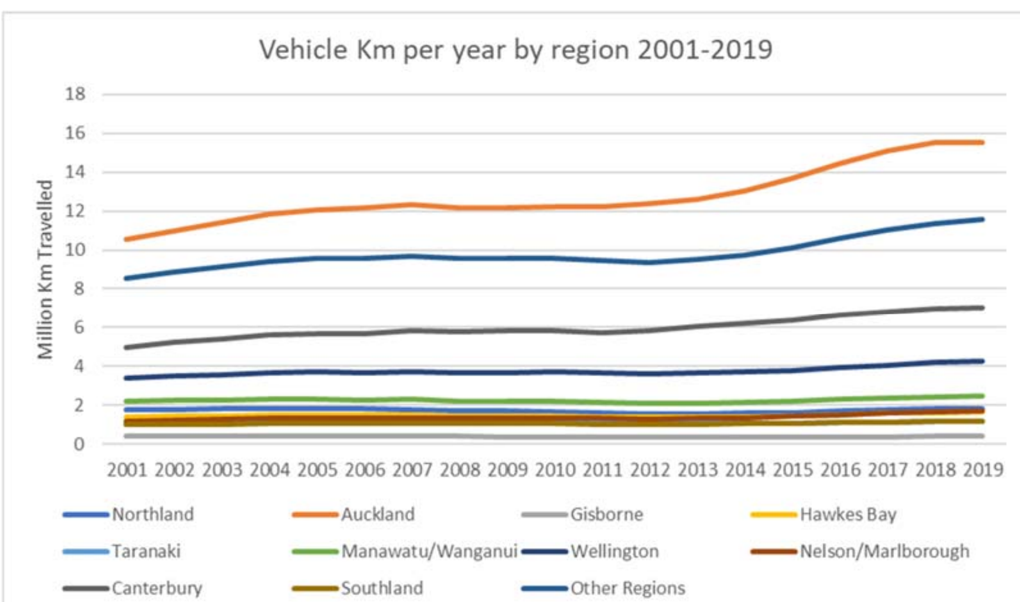

Figure 5 Vehicle Kilometres travelled by region NZ 2001-2019 (Ministry of Transport 2021)

CHARGING AS A MEANS OF ROAD TRAFFIC CARBON REDUCTION

To reduce carbon emissions from road transport, there are several avenues in terms of taxing, charging or pricing that might be utilised, with different objectives and resultant outcomes. This section discusses examples of vehicle sales tax, fuel tax, congestion charging and emissions-linked charging.

Vehicle Sales Duty

Imposing a higher sales tax or duty on new (or potentially imported used) vehicles that have high CO_2 emissions, is an attempt to influence buyers towards more fuel-efficient choices. The average light vehicle in New Zealand currently has carbon dioxide emissions of about 171 grams per kilometre. The Government is aiming to get that down for new vehicles to 105g/km by 2025, a standard met by Japan in 2014 and Europe in 2020.

The Government are working to introduce the “Clean Car Import Standard” aimed at achieving the overall reduction on average emissions from the NZ vehicle fleet over time. It is intended that the Clean Car Standard will decrease the price of low emission vehicles, including electric vehicles (EVs), and increase the price of higher-emission vehicles, both new and imported used.

While the details of the scheme are still under development, previous indications have suggested that it could mean about $8,000 off the price of new or near-new imported EVs. Fuel-efficient petrol and hybrid cars would also be cheaper, while the heaviest polluters would cost $3,000 more. Vehicles with middling fuel efficiency would face neither a discount nor a fee.

This proposal has the potential to assist in reducing the carbon emissions from road transport over the medium to long term but is unlikely to make a dramatic impact in the short term, given that the average age of the NZ light passenger fleet is about 15 years and this has been increasing rather than reducing over the last few years. There is a notable current gap in the availability of fuel efficient single and double cab utes, which account for the #1,2,5,6 and 9^{th} highest selling light vehicles in NZ over the past three years (Figure 7). These five models have an average CO2 emission of over 200g/km. It is debateable whether a $3,000 tax on top of the $50,000 price tag for a new Ford Ranger is likely to change a prospective purchaser’s choice, but if a hybrid version of the same model (rumoured to be launched in 2022) was to become similarly priced due to a relative $11,000 tax difference, it would perhaps then be more likely that more customers would choose the lower emitting variant.

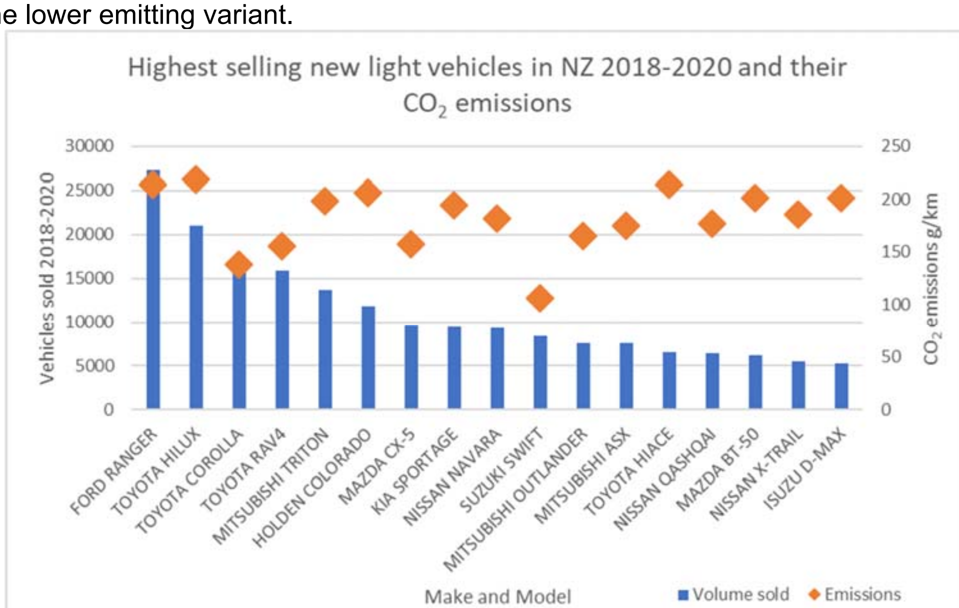

Figure 6 Highest selling light vehicles in NZ 2018-2020 (MIA 2021)

Fuel Tax

NZ has had a fuel excise tax for many years, currently the total tax proportion of retail petrol price is about $1.15 per litre. The fuel excise is directed into the Land Transport Fund, which largely pays the maintenance and upgrade of the road network and public transport fare subsidies.

In July 2018, Auckland Council imposed a Regional Fuel tax of 10 cents per litre on top of the general excise tax, hypothecated towards upgrades to the Auckland transport system, including both road and public transport projects.

There are several advantages to a fuel tax compared to other road charging schemes, in terms of delivering on the objective of carbon reduction from road transport, namely:

- It is a true user pays system, the more fuel used by an individual (or company) the more tax is paid. Thus, drivers with high mileage and drivers of fuel inefficient vehicles, who emit the most CO_2, will pay the most tax.
- It is relatively easy to implement and collect through retail sales.
- It is easily understood by users, who do not have to register, make extra payments or, in general, work out their options

The Land Transport New Zealand Research Report 331 "Impacts of fuel price changes on New Zealand Transport" (Kennedy and Wallis, 2007) concluded that petrol prices have a discernible impact on petrol consumption, but that the "elasticity" (or likelihood of behaviour change) varied between urban peak, urban off peak and rural travel, with urban peak travel (mainly commuting) being less responsive, despite often having more available alternatives such as public transport.

Kennedy and Wallis' modelling suggested that the impacts of a 10% (real) rise in petrol prices on consumption per capita would be:
• in the short run (within 1 year), a fall of about 1.5%;
• in the medium run (within 2 years), a fall of about 2.0%.

Current retail fuel prices (February 2021) in Auckland are about $2.10 per litre for 91 Octane. A 10% increase would thus be about an extra 20 cents per litre, double the Regional Fuel Tax (RFT) of 10 cents per litre introduced in July 2018.

The price of fuel in Auckland has varied considerably, with retail petrol price increasing from about $1.60 per litre in 2009 to nearly $2.50 in late 2018 after the introduction of the RFT (Figure 7). Over this period, petrol sales have remained fairly constant, while diesel sales have increased steadily, reflecting the fleet changes shown in Figure 2. Figure 7 shows that there were two periods when total fuel sales decreased, one in 2012, when 91 Octane petrol started to regularly cost more than $2 per litre and diesel over $1.50, and again in late 2018, after the introduction of the Regional Fuel tax.

This indicates some price sensitivity in fuel consumption as forecast by Kennedy and Wallis. However, to make a significant impact on carbon emissions, a fuel tax would need to be much higher than the Auckland RFT.

To achieve a 20% reduction in transport carbon emissions, for example, Kennedy and Wallis' model suggests a doubling in fuel price would be required (e.g. a tax increase of about $2 for petrol and $1.50 for diesel). While this level of taxation could raise considerable funds to invest in alternatives to driving, it seems unlikely that such a large tax would have much political or public support.

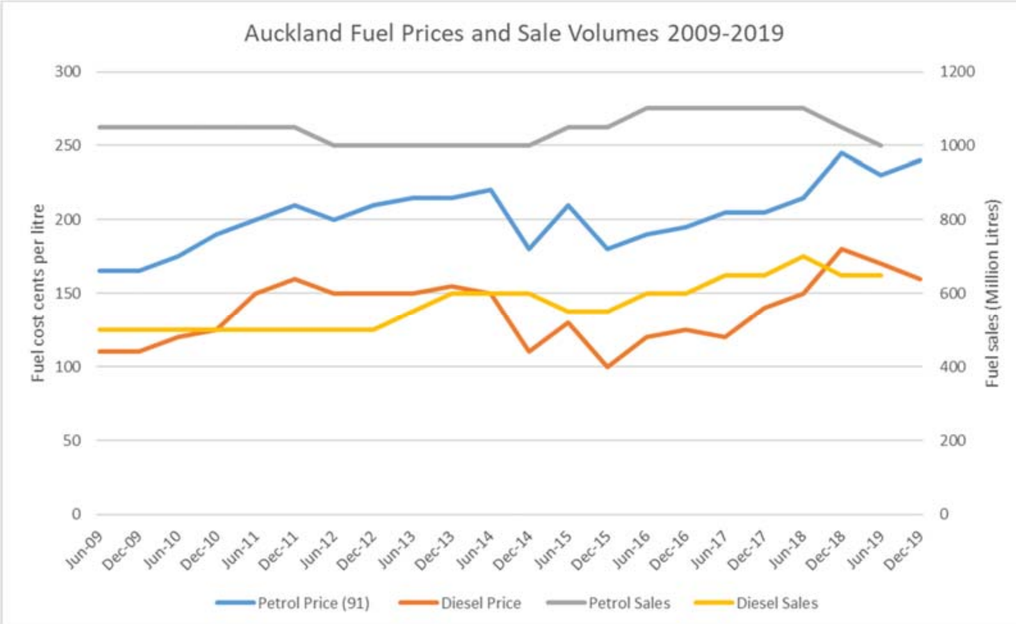

Figure 7 Auckland Fuel Prices and Sales 2009-2019 (data from Auckland Transport)

Congestion Charging

Congestion pricing is aimed at improving the performance of the transport network by charging some or all road users a fee to drive on all or certain roads within a defined area, usually during peak demand periods. There are generally four types of congestion pricing schemes in operation around the world as follows:

1. Cordon Charging: drivers are charged for crossing a cordon or ring across a series of roads at specific times of day, typically to manage demand. Cordon pricing does not charge for traffic movements that occur completely within the cordon. Stockholm introduced this system in 2007.
2. Area Charging: vehicles are charged for crossing a ring or driving within that ring at specific times of day, typically to manage demand. London introduced this system in 2003.
3. Corridor Charging: vehicles are charged to use one or more roads in a specific corridor or corridors. Singapore currently uses this system, introduced in 1998, but is proposing to change to:
4. Network Charging: vehicles are charged based on a combination of the time of day, location and distance travelled.

Congestion charging is, as it says on the label, designed specifically to reduce congestion in cities, rather than to reduce fuel use or CO_2 emissions. Reduced emissions are usually a desirable by-product rather than a stated objective.

One problem with charging to reduce congestion is that drivers will often seek alternatives, in terms of route or time, to avoid the charge, rather than the desired response of changing to more efficient modes or not making the trip at all. This can result in a small reduction in total trips, and some increased trip lengths including the use of less suitable local roads if this avoids the charge.

Another problem is that reduced congestion can attract new trips that are less price sensitive and more time sensitive (like taxis and couriers), so that the capacity freed up by the charge is reduced over time. London addressed this by reallocating street space to buses and active modes, reducing vehicle capacity. While this led to fewer vehicles within the cordon, the travel times within the cordon did not improve as expected by the public.

The Singapore system started with a manual charging system as long ago as 1975, converting to electronic road pricing (ERP) in 1998. The Singapore system charges for the use of a network of expressways and arterial roads at peak periods. The LTA reports that the ERP scheme has resulted in traffic decrease of about 13% during operational hours. Other studies have suggested that the scheme merely moved congestion to other non-charged roads or at other times.

In Stockholm, where the objectives were to reduce traffic congestion, improve urban environment, and support urban highway projects and PT infrastructure, the reported effect on vehicle emissions has been a reduction by 10-15% in the inner city. This is attributed to a reduction in (non-exempt) vehicles crossing the cordon of about 20%. The charge is between NZ$2 and $6 for every crossing of the cordon, with a maximum daily charge of about NZ$17.

In London, the scheme objectives were to reduce high traffic flows in central London area and raise investment funds for London's transport system. 2010 reporting (C40.org, 2011) suggests a 16% reduction in road transport CO_2 emissions within the charging zone, amounting to 30,000 tonnes annually. Approximately half of this was due to 75,000 fewer vehicles daily and half due to the remaining traffic experiencing less congestion. The London-wide CO_2 reduction is estimated at around 100,000 tonnes, ~1% of London's total road traffic CO_2.

The daily charge for driving within the zone is now £15 ($30). Free access to the congestion charge zone is granted to all-electric cars, some plug-in hybrids, and any vehicle that emits 75 g/km or less of CO_2 and have a minimum 20-mile zero emission capable range. This free access is planned to be removed at the end of 2025.

London Emissions-Linked Charging Schemes

As of 2019, there are now three separate pricing mechanisms in London, the central London Congestion Charge, and the Low and Ultra-Low Emissions Zones.

Designed to improve air quality in the city, London has introduced more stringent vehicle emission regulations over the past 12 years, introducing the Low Emission Zone in 2008, followed by the Toxicity Charge (T-charge) in 2017, and latterly the ULEZ in April 2019.

Low Emissions Zone (LEZ)

The Low Emissions Zone covers most of the Greater London area (1580 sq km) 24/7 and enforces a £100 penalty charge on any commercial (>3.5 tonne) vehicles that fail to meet the emissions standard, which was originally Euro III until 2012, Euro IV up until 1st March 2021 and is now Euro VI. In the latest incarnation, vehicles not meeting Euro IV standards now are charged £300 per day.

Toxicity Charge

The Toxicity charge was introduced in October 2017 in the existing Congestion Charging Zone to address record poor air quality. Vehicles that did not meet Euro 4 standards, typically those diesel and petrol vehicles registered before 2006, were charged £10 to enter the central zone during Congestion Charging hours (in addition to the Congestion Charge). In December 2017, TfL said that the charge had cut the number of these heavily polluting vehicles by around 1,000 per day, with the remaining 2,000 paying the £10 charge. However as further 3,000 vehicles are eligible for discounts (due to Blue Badges etc.) the actual reduction in heavily polluting vehicles is around 15%.

Ultra-Low Emissions Zone (ULEZ)

On 8 April 2019, the Ultra-Low Emission Zone (ULEZ) was introduced, which applies 24/7 to vehicles which do not meet the emissions standards: Euro 4 standards for petrol vehicles, and

Euro VI for diesel and large vehicles. The purpose of the ULEZ is to improve air quality in and around central London by reducing the number of older more polluting vehicles that enter the central zone. Unlike the Congestion Charge (which operates Monday to Friday between 07:00 and 18:00) the ULEZ operates 24 hours a day, every day of the year. Vehicles must meet strict emission standards to drive in the ULEZ area:

- Euro 4 for petrol cars and vans (vehicles less than fourteen years old in 2019)
- Euro 6 for diesel cars (vehicles less than five years old in 2019)
- Euro 6 for diesel vans (vehicles less than four years old in 2019)
- Euro 3 for motorcycles and other L-category vehicles
- Euro VI for lorries, buses and coaches
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Vehicles that do not meet these standards must pay a charge (over and above the Congestion Charge):

- £12.50 per day for cars, motorcycles and vans
- £100 per day for lorries, buses and coaches

From October 2021, the ULEZ will be expanded to cover the Inner London area within the North and South Circular Roads.

Euro emissions standards so not specifically target CO_2 emission, but concentrate on emissions of Carbon Monoxide (CO), NO_x, hydrocarbons and particulates. However, it is likely that vehicles which conform with higher Euro emission standards are also those which use less petrol and diesel per km driven, thus the reduction in use of non-complying vehicles is expected to reduce CO_2 emissions overall, even if this is not the primary objective.

The ULEZ six-month monitoring report (Greater London Authority October 2019) reported a preliminary estimate of a 4% decrease in CO_2 emissions in the central zone. It also reports a decrease in non-compliant vehicles detected within the zone of nearly 40%, compared with an increase in compliant vehicles of 15%, against an overall decrease of 6% in detected vehicles.

December 2020 monitoring report suggest that, notwithstanding altered travelling patterns due to Covid-19, the pattern in continuing with the non-compliant vehicle detection proportion down to 15% (from 39% in March 2019 and 26% in September 2019) and the total number of non-compliant vehicles detected dropping to 11,900 from 32,100 in 2018.

The Greater London Authority now reports that CO_2 emissions in the central zone are estimated to have reduced by 12,300 tonnes, a reduction of 6 per cent because of the ULEZ (London.gov.uk Feb 2021).

Future Strategies

With London aiming to be a carbon zero city by 2050, further evolution of congestion and emissions charging is planned. The London Environmental Strategy proposes that between 2020 and 2035, the GLA will develop a new, more sophisticated way of paying for road use, integrating existing and proposed emissions-based and congestion charging schemes.

AUCKLAND'S CONGESTION CHARGING PLAN

The Congestion Question (TCQ) project is a technical investigation by officials from six government agencies (the Ministry of Transport, Auckland Council (AC), Waka Kotahi NZ Transport Agency (Waka Kotahi), Auckland Transport (AT), The Treasury and the State Services Commission) to consider whether there is a case for introducing a congestion pricing scheme for Auckland and test the effectiveness of charging options.

Like the schemes reviewed in the previous section, the Auckland proposal is designed and evaluated against its ability to reduce the attractiveness of driving, especially commuting into the city centre, by targeted charging. The objectives of the scheme are well demonstrated in the evaluation criteria used to assess options, and the weightings given to them as follows:

1. effectiveness in reducing congestion (65%)
2. economic, social, environmental and safety considerations (20%)
3. efficiency, flexibility and wider considerations (15%).

These weighted evaluation criteria suggest that the environmental impact (e.g. reduced CO_2 emissions) is not an important objective for the Congestion Question study, as one fourth of 20% suggesting that improved environmental outcomes is worth just 5%, with compared to reduced congestion (lower travel times) being 65%.

The shortlisted options evaluated were largely geographically differentiated as follows:
- City Centre Cordon
- Isthmus Area
- Target Congested Corridors
- Combination (City Centre Cordon and Target Congested Corridors)
- Regional Network – all congested roads during congested periods.

Options were evaluated using various metrics (mostly derived from a strategic transport model) and the city centre cordon and the strategic corridors options are recommended to take forward to the next stage. In terms of CO_2 reduction, none of the shortlisted options showed a greater than 1% reduction in CO_2 emissions, with the city centre cordon reduction being just 0.1% and the strategic corridors being 0.8% reduction (Figure 8).

Evaluation metric	Shortlist option				
	City Centre Cordon	Isthmus Area	Strategic Corridors	Combination	Regional Network
Transport assessment					
No. of vehicle trips reduces by:	0.4%	4.7%	1.3%	1.7%	2.2%
Average vehicle travel time reduces by:	0.8%	5.4%	6.7%	7.6%	8.2%
Total travel time delay reduces by:	4.2%	26%	30.4%	34.6%	32.8%
Time spent in severe congestion reduces by:	2.5%	13.8%	16.1%	19.0%	20.3%
Freight vehicle kilometres travelled (VKT) in severe congestion reduces by:	1.6%	10.7%	22.4%	25.7%	23.9%
No. of jobs accessible within a 30 minute drive increases by:	1.9%	17.9%	14.6%	18.9%	17.1%
CO_2 emissions reduced by:	0.1%	0.3%	0.8%	0.7%	0.8%
Other emissions (VOC, NO_x, PM_{10}, $PM_{2.5}$) reduce by:	0.1%	0.3%	0.7%	0.8%	0.8%

Figure 8 Congestion Question Short List Evaluation results (Congestion Question Main Findings Report July 2020)

The Congestion Question study has recommended a way forward for Auckland road pricing which is forecast to be effective in reducing congestion. However, the Government's priorities have shifted away from reducing congestion towards reducing carbon emissions. Are the original terms of reference for the study still valid in 2021? If reducing CO_2 emissions were a specific objective and given a higher weighting, what different options may have emerged into the short list? What would be an appropriate target for carbon emissions from a charging scheme?

CONCLUSIONS AND RECOMMENDATIONS

The CO_2 emissions from road transport in New Zealand are increasing and recent trends suggest that emissions are likely to get worse before it gets better, as more kilometres are driven, and less efficient vehicles dominate our sales figures.

This paper has looked at a wide range of existing and proposed 'charging" schemes: vehicle purchase incentives, fuel taxes, road and congestion pricing, and emissions penalties.

Of these, only the proposed NZ Clean Car Import Standard is specifically designed to result in reduced CO_2 emissions from road transport, the others are designed to raise funds for transport improvements, to reduce traffic congestion, or to improve air quality. Any reductions in CO_2 emissions arising from fewer vehicle trips of more efficient vehicle choices are a desirable but relatively minor outcome in these schemes.

The overwhelming conclusion from this overview is that there are a several fiscal levers to pull that could change behaviours sufficiently to result in a substantial reduction in CO_2 emissions from road transport in Auckland. The key to developing an effective yet socially acceptable charging scheme appears to lie in establishing the appropriate objectives for a scheme so that it can be designed to deliver upon the desired outcome of CO_2 reduction, rather than relying on reduced CO_2 emission as a by-product of a scheme designed to deliver different outcomes.

The **recommendations** of this review of the potential for charging mechanisms to deliver CO_2 reductions are therefore:

1. The NZ Clean Car Import standard, including the discount for low emission vehicles, has potential to substantially improve the fuel efficiency of the NZ fleet over time, and as a net cost neutral scheme should be implemented alongside any other direct charging scheme.

2. Fuel taxes are an appropriate and simple method of raising revenue for transport system funding and both national and regional fuel taxation impose a tax that is equitably relative to total fuel use, so should help encourage both less driving and more economical vehicle choices\. However, a very substantial increase in fuel tax would be required to deliver a meaningful reduction in fuel use and CO_2 emissions in isolation of other measures.

3. The Auckland Congestion Charge proposal should be redesigned to improve the outcomes for reduced CO_2 emissions. A hybrid scheme that includes tiered charges for road use relative to the CO_2 emissions of the vehicle being used could result in both positive outcomes for reduced congestion and substantial decreases in CO_2 emissions. The type of scheme under investigation to combine / replace the London Congestion Charge and ULEZ schemes might be applicable to Auckland if specifically designed to reduce CO_2 emissions.

A combination of all three of the above, designed as a single package to ensure that the total tax burden is appropriate and as equitable as possible, ought to provide enough levers to positively influence people's decisions about how, where and when to travel. Crucially the system needs to be developed with the focussed outcome of reducing CO_2 emissions from road transport as its primary objective. Reducing congestion in our cities and on our busiest highways could be a secondary objective.

If successful in Auckland, the hybrid carbon / congestion pricing scheme could be rolled out nationwide, potentially with GPS development, as proposed for Singapore. This could start with the other major city centres, followed by our most congested inter-city highways.

Key to acceptability would be that revenues are relatively cost neutral, while directly linked to carbon emissions, such that low mileage users and those who drive the most economical vehicles see a reduction in total transport costs, while high mileage drivers and the highest emitting vehicles pay more. The freight industry in particular would need to be assured that competitiveness and commercial viability will not be adversely affected, given the high mileages and fuel consumption of their fleets

What is crystal clear is that there is no time to lose. NZ is committed to (among other targets) a 6 million tonne reduction (from 2017 levels) in annual CO_2 emissions from transport by 2035. Against a background of population increase and recent increases in NZ transport CO_2 emissions of about 3% per year since 2013, even keeping at 2019 levels will be challenging.

To get to the 2035 target would require an approximately 3% annual reduction from 2021 - if the reduction could be started immediately and would deliver nearly 100 Million tonne reduction in CO_2 emissions by 2040 compared to remaining at the 2019 level. (Figure 9).

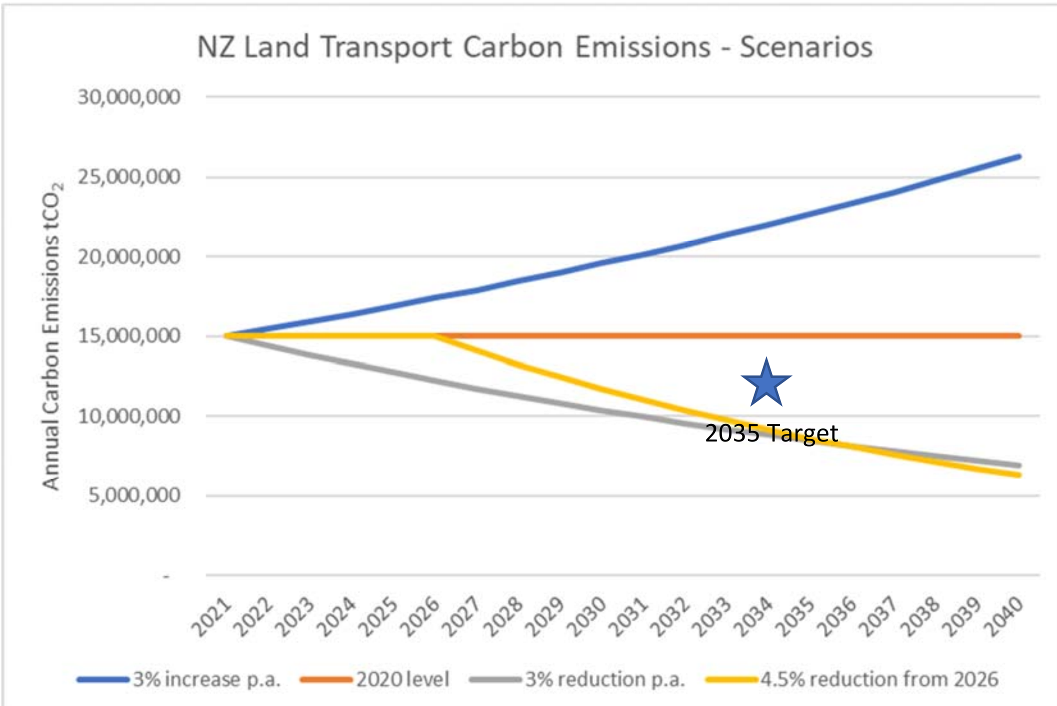

Figure 9 Potential Carbon Emission Future Scenarios

However as also shown (by the yellow line) on Figure 9, if it takes 5 years to start to reduce carbon emission below current levels 2026, a 50% higher reduction rate (about 4.5% per annum) is required to meet the 2035 target, this presumably would require considerably more stringent interventions (such as 50% higher charges) which may be less acceptable to the population.

Much easier to achieve if we can start now. Charge!

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