Diesel matters: accelerating the light diesel vehicle endgame in Aotearoa New Zealand

John Horrocks, Nick Wilson

ABSTRACT

Air pollution from diesel-powered vehicles is likely to be contributing substantial harm to health in Aotearoa New Zealand, as well as making it harder for this country to meet its international climate change commitments. There are a lack of controls and outdated standards applied to diesel vehicles in New Zealand, and there is scope to extend the monitoring of emissions. A comprehensive list of interventions that would assist with the phase-out of light diesel vehicles and reducing their emissions during the transition has been compiled. This list includes regulatory interventions such as bringing forward the year in which the Climate Change Commission proposes to ban imports of internal combustion light vehicles (ie, from 2035 to 2025). Also detailed are fiscal measures (incentives and disincentives) and improvements to information for consumers at point-of-sale.

The relationship between air pollution and health, including premature death, is well-recognised. The Global Burden of Disease (GBD) study estimated in 2020 that in the previous year there were 6.7 million premature deaths globally from air pollution (ambient particulate matter and ambient ozone pollution). This number comprised 11% of all female deaths and 12% of all male deaths.[1] Another study has produced an even higher figure: 8.7 million premature deaths annually from fine particulate matter ($PM_{2.5}$) produced by the burning of fossil fuels.[2]

In this viewpoint, we have concentrated on the impact on air pollution of New Zealand's light diesel vehicles, which have made up a growing proportion of the diesel fleet since the year 2000. This category covers vehicles that have a gross mass of under 3,500 kilograms. It includes passenger cars and vans, but recent growth in the number of light diesel vehicles has been concentrated in the commercial fleet, which contains utility vehicles (utes), goods vans, motor caravans, lighter trucks and buses. Since 2000, the proportion of light commercial vehicles powered by diesel has increased from 44% to 74%.[3]

The popularity of diesels has created a potentially powerful lobby for the continued use of this fuel and poses a challenge to the proposals by the Climate Change Commission (CCC) for a rapid decarbonisation of the transport sector and a shift to electric vehicles. According to the CCC's 2021 draft timetable, no further internal combustion light vehicles would be imported after 2035.[4]

In order to clarify the steps that would need to be taken to achieve the CCC's transport goals, we assessed how much is known about the local ambient concentrations of the most harmful components of diesel emissions, nitrogen oxides (NO_x) and $PM_{2.5}$: that is, how they are being monitored and how well-informed about their emissions are the purchasers of diesel vehicles. A reduction in these pollutants would comprise an important health co-benefit to any initiatives to control carbon emissions from diesel. We also examine some of the actions that could accelerate the removal of light diesels from the vehicle fleet.

Since 2013 there has been a trend away from petrol cars towards large diesel-powered sports utility vehicles (SUVs) and

utes.[3] Modern versions of the latter have incorporated the tray into the bodywork, and twin cab models can often be seen in the country's towns and cities, where they are used as family vehicles.[5] Because New Zealand's popular utes fall under a commercial designation, owners who claim that they use their vehicle for business can enjoy tax advantages such as depreciation of the asset, exemption from fringe benefit tax, rebates of goods and services tax (GST) and the ability to offset running expenses against income. These attractive incentives go some way to explaining why Ford proudly labels its Ford Ranger utility vehicles as "NZ's Favourite Workmate,"[6] a reasonable claim as the Ranger has been the country's highest-selling new vehicle since 2015, with 7975 new Rangers registered in 2020.[7] All these models of the Ranger in New Zealand run on diesel.

At a time when sales of light diesel vehicles are falling in other countries and there are restrictions on their use in many European cities,[8,9] New Zealanders continue to have a love affair with diesel. Most SUVs imported into the country are available in diesel versions, including the Kia Sportage, the fifth-highest selling new car in 2020. The popular Toyota Hiace range of vans and camper vans also includes diesel options. In 2019 diesel vehicles accounted for 19.8% of the fuel use in New Zealand's light fleet.[3]

Health impacts of diesel emissions

Diesel vehicles are heavy producers of NO_X and $PM_{2.5}$. The main source of nitrogen dioxide (NO_2) from on-road emissions in New Zealand comes from diesels, which contributed 70% of the 47,800 tonnes of NO_2 produced by vehicles in 2015.[10] Diesel emissions contain far more NO_X than emissions from petrol engines because diesels operate at a higher pressure and can also operate at a higher temperature under some driving conditions—factors that during combustion favour the creation of NO_X from the nitrogen and oxygen in the air/fuel mix. NO_2 itself is, in turn, produced when emissions of NO_X react with other chemicals in the air. $PM_{2.5}$ resulting from the use of vehicles can be formed by mechanical abrasion from traffic (eg, from wear on tyres), but its contribution from traffic is mainly found in the form of soot as a result of incomplete combustion.[11,12]

Both NO_X and $PM_{2.5}$ are associated with a variety of harms to health.[10] NO_2 irritates the respiratory tract and can lead to long-term cardiovascular damage, and diesel engine exhaust has been identified as a cause of lung cancer.[13] The increased mortality within populations that are exposed to particulate pollution, even at low levels, is long-established.[14] A study of the impact of both ozone and $PM_{2.5}$ pollution on mortality among the 61 million Medicare beneficiaries in the US found that even at levels below those set by national air quality standards for $PM_{2.5}$, these pollutants were linked to a greater all-cause risk of death.[15]

New Zealand-based research has also linked air pollution exposure to increased mortality risks, with stronger associations for Māori.[16]

The most recent estimates for the year 2016 were for approximately 4,000 premature deaths from $PM_{2.5}$ and NO_2 combined for New Zealand (more specifically: approximately 2,000 deaths from for $PM_{2.5}$ from all sources and approximately 2,000 from NO_2 from road traffic).[17] Such estimates do not even include the health loss from disability (eg, from chronic respiratory disease and cardiovascular disease). Furthermore, a large study in London has linked typical diesel exhaust pollutants with more severe symptoms of mental illness in vulnerable individuals.[18]

The limited controls on New Zealand's light diesel vehicles

Diesels can be significant contributors to climate change through their emissions of carbon dioxide (CO_2). Although they have lower fuel consumption than petrol vehicles, each litre of diesel accounts for more CO_2 emissions than a litre of petrol.[19] Together with the sheer size of many diesel SUVs and utes in New Zealand, this means that the larger models in these classes can emit more than 200 grams of CO_2 per kilometre. This contrasts with the emissions of the country's highest-selling smaller car, the Toyota Corolla, the petrol versions of which are claimed to produce less than 140g/km.[8]

New Zealand consumers are not well-informed about the fact that diesel vehicles also produce NO_x and $PM_{2.5}$. A cursory chat with salespeople at car yards makes this clear, and the manufacturers' figures for NO_x emissions from diesels are not displayed at the point-of-sale, unlike the CO_2 data for models sold locally. CO_2 figures are published at the point-of-sale, on the motor distributors' websites and by the New Zealand Government website Rightcar (though Rightcar does provide an opaque and poorly characterised composite rating for pollutants other than CO_2).

Apart from this lack of information, the control of emissions from New Zealand's light diesel fleet is held back by the country's weak and outdated emission standards for new vehicles and newly imported used vehicles. Since November 2016, importers of light vehicles have had to meet the emission standards set by EURO 5 or its equivalents, like Australian Design Rule (ADR) 79/04, JAPAN 09 and US 2007.[20] EURO 5, however, was superseded as long ago as September 2014 by the new requirements set by EURO 6. EURO 6 sets a limit for NO_x emissions of 0.08g/km, a 67% reduction on the EURO 5 limit. In order to meet the more stringent limits and tests that must be met by EURO 6 vehicles, the particulate filters on the exhaust systems of EURO 5 models must be supplemented by other devices. These may include a NO_x trap that uses a catalyst to reduce NO_x to nitrogen. Another process, selective catalytic reduction (SCR), uses an additive, AD Blue, which contains urea. This is injected into the exhaust and reduces NO_x to nitrogen and water.[21] As one might expect, these devices need expert maintenance. Even the particulate filters on EURO 5 models need regeneration through occasional periods of high-speed driving. Beside these innovations, the later versions of EURO 6 assess emissions by tests that also reflect real-world driving conditions, rather than just the laboratory results that supported earlier standards.

The protective value of the EURO 5 standard currently used in New Zealand for new and used additions to the light vehicle fleet is doubtful, as NO_x emissions are likely to be far higher than the official limit. A study conducted for the German Environment Agency (Umweltbundesamt) found that if temperature changes were taken into account and measurements were also taken under real-world driving conditions, EURO 5 diesel vehicles could exceed the limit for NO_x of 0.18g/km by over 400%.[22] The health implications of this gap between testing under laboratory conditions and real-world driving conditions was illustrated by a study of the effect of diesel emissions in 11 major markets. It estimated that, because of their role as ozone and $PM_{2.5}$ precursors, excess NO_x emissions were linked in 2015 to approximately 38,000 premature deaths worldwide. These "excess" emissions were those observed during on-road driving over and above those recorded by testing under laboratory conditions.[23]

In May 2021, the Ministry of Transport canvassed motor industry opinion over its suggestion that stricter emissions requirements for imported used diesel vehicles could come into force after January 2022 and new vehicles a year later. The immediate response from the Vehicle Industry Association was that 90–95% of used imported models would be banned as a result[24]—an indicator of the degree to which New Zealand has become a haven for polluting vehicles.

EURO 6 does set more demanding standards for NO_x, but there are questions about how many new diesels can actually meet these standards when in use. Results for different passenger brands vary widely and only 10% of EURO 6 cars tested by the International Council on Clean Transportation passed the NO_x standard on the road.[25] Official figures from vehicle manufacturers also need to be treated with scepticism, quite apart from any deliberate falsification of test bed results, as seen in the "Dieselgate" scandal with Volkswagen in 2015.[26]

As outdated as EURO 5 may be, it does set limits for emissions besides CO_2, including limits for NO_x and PM. The limit for PM is a measure based on the total mass of particles in exhaust emissions. The majority of particles are very small (less than $PM_{2.5}$), but a relatively few larger particles contribute most of the mass.

One unintended benefit of New Zealand's tardy adoption of newer emission rules may be the opportunity to set in place measures to stop motorists from tampering with the various technologies used to reduce diesel

emissions. As well as exhaust system filters and exhaust gas recirculation, these include engine software and on-vehicle diagnostic systems to monitor emissions. The potential for tampering has been recognised by New Zealand industry groups such as the Motor Industry Association, and in 2016 the Ministry of Transport began work on how legislation and associated operational actions could prohibit this practice. The New Zealand Transport Agency's 2021 requirements for urban buses explicitly prohibit these practices in the case of buses.[27] The seriousness of tampering is demonstrated by the fact that over the previous decade in the US, at least 550,000 owners of diesel pickup trucks (utes) have disabled or modified these control devices. The US Environmental Protection Agency (EPA) estimates that the polluting impact of this tampering has resulted in emissions equivalent to those produced by an additional nine million (compliant) pickup trucks.[28] The blatant use of this practice has been seen by prosecutions in which offenders have been found to have used defeat devices on diesels with names such as Deviant Race Parts, Alligator Diesel Performance and Adrenaline Performance. Some modified vehicles can also "roll coal", a kind of "exhaust-belch" of sooty exhaust that can be released on demand. Rolling coal is used as a political challenge to protesters about liberal causes, as well as drivers of eco-friendly cars, such as Prius owners.[29]

In New Zealand, more old vehicles are kept in use than in countries with a comparable degree of motorisation, such as Canada, the US and Australia. In 2018 the average age at exit for all light vehicles bought new was 18.9 years, and for used imports the figure was 20 years.[3] This feature of the country's vehicle fleet means that it includes relics from a time when standards for fine particle emissions were far laxer than the current requirement for new imports. For the heavier diesel fleet, buses are among the more visible examples of the local tendency to keep older vehicles in service, even when there are strong efforts by local and regional authorities to phase them out. In Wellington, for example, 79% of the fleet is now EURO 5 or above, including 10 electric vehicles.[30] The remaining ancient buses can be identified easily enough by the black exhaust that emerges from their tailpipes as they travel through central city streets like Lambton Quay. Similar buses continue to enjoy second careers as school buses or be used on contract. This can be seen in old Volvo buses operated in these roles by Mana Coach Services.

They met EURO 3 emission standards when they entered the passenger transport fleet, but these are criteria that date back to the year 2000. EURO 3 included an allowable PM level in exhaust five times higher than applies to later EURO 5 imports. During operation, this will be an underestimate, in view of the age of these buses and the fact that emissions tests for vehicles earlier than EURO 6 were not conducted under real-world driving conditions.

Given the above issues, further development of high-quality monitoring of diesel emissions in New Zealand is important. In the Appendix we discuss the current arrangements and scope for further improvements.

Accelerating the light diesel vehicle endgame and reducing harmful emissions

In Table 1 we outline potential interventions to accelerate the light diesel vehicle endgame and to reduce air pollution during this transition. Some of these interventions apply to all vehicle use but have particular relevance for diesels (the first part of the table), and some of these would have health co-benefits via other pathways (eg, increased physical activity from infrastructure to support walking and cycling). Some of these steps have been considered by the CCC[31] and the Ministry of Transport,[32] but others do not appear to be under substantive discussion (eg, scrappage schemes). We discuss such schemes and other precautionary actions in the text below.

Extensions to the Clean Car Discount

The Clean Car Discount, or feebate scheme, was proposed by the Labour government in 2019[33] and is now a key part

of the transport strategy of the CCC. It has two main features. The first is a Clean Car Standard, which sets goals for importers of average grams of CO_2 emitted per kilometre among the vehicles they bring into the country each year. The second is a combination of charges at the time of purchase for vehicles that are heavy emitters of CO_2 and discounts for less polluting vehicles (Clean Car Discount).[34] The aim is to encourage motorists to move towards smaller cars and hybrid or electric vehicles (EVs). The Clean Car Discount for new imports of new and used EVs and plug-in electric hybrid vehicles has already applied from 1 July 2021, with the maximum discount at $8,250 for new EVs.

The next stage of this scheme is a first step towards controlling the dominant position of large diesels in the light vehicle fleet. From 1 January 2022, large diesels will attract charges at the time of purchase. Detailed charges are still to be finalised (at the time of writing), but in the 2019 version, a buyer of a new Ford Ranger would pay an additional $2,175, whereas a buyer of a small car, such as the Toyota Corolla, would receive a discount of $600 because of the vehicle's much lower CO_2 emissions. The proposed charges for a large diesel-powered ute like the Ford Ranger are controversial enough to have led to a rush to buy such vehicles before the scheme comes into effect, yet these charges are minimal by comparison with proposals in other jurisdictions for charges that could be as much as 20 times higher.[35]

A serious limitation in this scheme is that it applies only to vehicles that are newly imported. In the case of diesels, it does not take into account the numbers of large diesel vehicles already in the country and their longevity.[3] It is also based on CO_2 emissions and overlooks the variety of other hazardous emissions produced by diesels. In order to more rapidly reduce carbon emissions and other hazardous outputs, it would be better to make an annual charge at the time of registration for all larger light vehicles, including diesels, not just new imports. This charge could be differentiated by the size and type of vehicle, as in the feebate scheme proposals, but at a lower overall rate. That would overcome the disincentive to buy a new vehicle, an unintended consequence that could ensure only older and more polluting diesels are being used during the transition to a low-carbon vehicle fleet. At the same time, it would signal to all diesel owners that large diesels are a costly transport option. Additional charges based on the NO_x and PM emissions from diesels could help to differentiate them from similar models that run on petrol.

The Clean Car Standard is sometimes described as a fuel efficiency standard, as in the 2021 Ministry of Transport's Green Paper on pathways to net zero for transport emissions by 2050.[32] Carbon emissions are closely related to fuel usage, and the merit of this standard is that it applies to all fuel types and prioritises carbon. As a performance measure, however, the use of the phrase "fuel efficiency" needs to be distinguished from actual fuel economy standards, which have been set in all of the 24 OECD countries apart from Australia, Russia and New Zealand.[36] This further evidence of a long-standing lack of pressure to improve the fuel economy of the New Zealand vehicle fleet explains why it is one of the most fuel-hungry in the OECD.[36]

In its submission to the first report of the CCC, the Motor Industry Association made a strong case that the CCC's focus on a rapid shift to EVs overlooked the fact that the current supply chain for vehicles is closely linked to Australia, and that the small size of the local market means that New Zealand has little prospect of influencing what global manufacturers should build for us, especially as production is geared towards left-hand-drive vehicles.[37] The CCC's views about the future of EVs may not go as far as entering the "realm of fantasy," as the Motor Industry Association argued, but supply issues for new EVs and the durability of the current fleet of diesels indicate that incentives for getting older diesels off the road will also be very important. The accelerated retirement of these polluting vehicles will not be achieved simply by the introduction of the Clean Car Discount scheme in its current form.

Vehicle scrappage schemes

New Zealand can learn from the example of other countries about how to plan for the scrappage of older and polluting vehicles. In the US, for example, there are detailed

protocols for replacing old school buses. In some cases there are rebates for this or for retrofits.[38] The limited scrappage trials run in New Zealand in 2007 and 2009 are mainly of interest now for the degree to which the participants were ill-informed before the trial about their options for getting rid of old vehicles.[39]

Fiscal incentives to scrap older vehicles could speed up their withdrawal from use, as well as being an equitable solution for lower-income families who may find it difficult to replace their vehicles. These could be funded by the income generated by the type of feebate scheme described above, or from Emissions Trading Scheme revenue. Actual disposal of old vehicles should be part of a nationwide scrappage scheme, as in Ireland. In the United Kingdom, distributors of particular brands of vehicles are also beginning to offer scrappage incentives for older vehicles instead of traditional trade-ins,[40] such as Hyundai with its Scrappage and Emission Reduction Scheme. New Zealand distributors could be encouraged to support such schemes.

Studies of gross emitting vehicles in the light vehicle fleet (defined as the 3% of the fleet that produce the most emissions) may in future provide a guide to which vehicles can be singled out for scrappage. These studies are discussed further in the Appendix.

Shifting perceptions and informing the public about the hazards of diesel

Light diesel vehicles have enjoyed years of heavy promotion based very much on a psychological aura of dominance and outright aggression. The most extreme example of the macho image of utes is the availability from several online suppliers of "truck nuts," a popular accessory for pickup trucks in the US. These are outsize and brightly coloured imitation testicles that can be hung from a vehicle's tow bar.

Vehicle size itself has also been emphasised as a positive feature of diesel vehicles, illustrated by the slogan in an advertisement for the 2019 Ford Ranger Raptor: "You're Going to Need a Bigger Garage."[41] Other attributes of these vehicles have names that associate them with predatory beasts: aspects such as "a muscular presence," appeals to urbanites that convey the vehicle's capacity to ride over "annoying" speed bumps, and the vehicle's "look"—"these look ready to scale mountains" was a description of the Ford Everest bi-turbo diesel.[8]

Marketing like this is at odds with a transition to a low-emissions economy. The CCC recognises that "significant changes to behaviour" will be required to realise its goals.[42] In the face of such advertising, behavioural change becomes more difficult. In similar fashion, the Motor Industry Association emphasises the importance of incentives if demand is to be shifted from popular models such as SUVs and utes, automatics and vehicles that are suitable for towing.

The Motor Industry Association points out that importers place orders for the models consumers want.[37] The impact of these consumer choices is exacerbated by the way manufacturers provide model versions to New Zealand that are less efficient than those supplied to countries that have regulated fuel efficiency standards.[43]

Another example of the need for better information for consumers is the controversy over the 2021 Clean Car Discount.[44] This reflects debates in Australia at the time of their 2019 General Election, when the governing Liberal Party claimed that the Opposition's call for a move towards electric vehicles and new emission standards would damage "tradies," kill the economy and represent an attack on four-wheel drive vehicles that would spell "the end of the weekend."[45,46] New Zealand's National Party used similar tactics later that year to attack an earlier version of the feebate scheme, but was forced by the Advertising Standards Authority to withdraw an advertisement that exaggerated the costs.[47] It is no surprise, therefore, that some of the more negative reactions to the current Clean Car Discount are not new. They indicate that there is a need for a vigorous strategy to alert consumers to the advantages of the scheme. This could include material about the need to move away from the country's most polluting vehicles, diesels.

Specific actions to shift public perceptions could have the following features:

- Mandatory information at the point-of-sale about the NO_x and PM emissions of diesel vehicles, in line with the information that is currently provided about CO_2 emissions and fuel economy.
- Mandated clear labelling of vehicles themselves to indicate their emission status, as required in Europe. In Britain, for example, the EURO standard to which a new car has been certified has been noted on the vehicle's registration certificate since September 2018.
- Explanatory information about steps to reduce the number of diesel-fuelled vehicles, to avoid misconceptions among groups such as farmers and tradespeople that their work vehicles will be unfairly targeted during the transition away from fossil fuels.
- A ban on all New Zealand marketing for older diesel vehicles that cannot meet the latest European emission standards. This would include almost all light diesels in the current vehicle fleet. Promotion about vehicles could be permitted only at the point-of-sale and could be limited to vehicle specifications.
- Government information material about the health risks of diesel emissions, in order to inform not only the motoring public, but organisations such as the Automobile Association, the Motor Industry Association, and motoring publications.

Conclusions

Air pollution from diesel-powered vehicles is likely to be contributing substantial harm to health in New Zealand, as well as making it harder for this country to meet its international climate change commitments. There are a lack of controls and outdated standards applied to diesel vehicles in New Zealand, and there is scope to extend the monitoring of emissions. A comprehensive list of interventions that would assist with the phase-out of light diesel vehicles and reducing their emissions during the transition has been compiled. This list includes regulatory interventions such as bringing forward the year in which the Climate Change Commission proposes to ban imports of internal combustion light vehicles (ie, from 2035 to 2025). Also detailed are fiscal measures (incentives and disincentives) and improvements to information for consumers at point-of-sale.

ISSN 1175-8716

Table 1: Framework of options for accelerating the light diesel vehicle endgame and reducing air pollution during the transition

Potential actors	Potential intervention/s
Impacting specifically on light diesel vehicles	
Central government	Bringing forward the CCC's proposed end date (2035)[31] on the permitted importation of internal combustion light vehicles (eg, to 2025, the year that Norway will *end the sale of all* fossil fuel-powered cars[48]).
Central government, local government, and vehicle distributors themselves	Vehicle scrappage schemes for light diesel vehicles. See text above for further details.
Central government	A ban on all New Zealand-based marketing for older light diesel vehicles that cannot meet the latest European emission standards. See text above for further details on how diesels are currently marketed and other steps to counter the momentum this gives to providers of these vehicles.
Central government	Mandatory information at the point-of-sale about the NO_x and PM emissions from light diesel vehicles.
Central government	Mandated clear labelling of light diesel vehicles themselves to indicate their emission status.
Central government	Explanatory information about steps to reduce the number of diesel-fuelled vehicles, to avoid misconceptions among groups such as farmers and tradespeople. See text above for further details.
Central government (Ministry of Health)	Informational material about the health risks of diesel emissions (especially at the time that related laws or regulations are introduced).
Central government, operationalised by workers doing WOF inspections	Requirements for pollution mitigation devices (to reduce NO_x and PM) on new light diesel vehicles from a specific date. Mandatory checking of such devices at warrant of fitness (WOF) inspections could follow (with appropriate fines for non-compliance).
Police	Tighter enforcement around obviously polluting diesel vehicles—at present drivers can avoid penalty if they claim that smoky emissions are unavoidable because the design of the vehicle's equipment is original and it would entail disproportionate effort or expense to remedy its faults.[49]
Potentially impacting on all vehicles but including light diesel vehicles	
Central government	Increasing fuel prices,[32] or increasing the price of carbon via further reform of the Emissions Trading Scheme. But preferable to these may be a more effective carbon tax,[50] with per capita annual pay-outs to all citizens (as "climate dividends").[51] The latter could actually ensure that low-income households are better off.[51]
Central and local government	Financial and regulatory support for the CCC's recommendations around: public transport, changes to urban form to support walking and cycling and remote working.[31]
Central government	Adoption of the latest Clean Car Standard and Clean Car Discount, but in the latter's case with the addition of an annual charge at the time of registration (also based on vehicle type and size). See text above for further details.
Central government (to empower local government), then local government to act	Establish low-emission zones in major city centres where only EURO 6 standard vehicles are permitted (eg, as per some European cities[9]).
Central government (to empower local government), then local government to act	Introduce transport pricing, with congestion charging and distance pricing considered in a Ministry of Transport Green Paper.[32] These can be potentially combined with subsidies (free public transport) and funding support for the uptake of low pollution transport modes (walking and cycling).
Central government and local government	Minimum parking prices nationally within inner-city areas and enhanced enforcement. Parking on roads that are popular cycle routes could also be prohibited.

Appendix

Monitoring of diesel emissions in New Zealand

Monitoring of emissions is critical, as it establishes where public exposure to them is likely to be at its highest and what trends in exposure are emerging.

Monitoring of NO_2

An indicator of the volume of diesel emissions in New Zealand is the data provided by a nationwide network of passive monitors managed by Waka Kotahi New Zealand Transport Agency (NZTA). These monitors record levels of NO_2 in selected cities, with a focus on monthly averages.[52] Because the monitoring sites are alongside the kerbside of roads, they record the immediate impacts of traffic—NO_2 levels drop quickly according to their distance from the monitors. The NZTA results are also supplemented by data collected from sources such as the Greater Wellington Regional Council (GWRC). They are based upon the assumption that NO_2 is useful as an indicator pollutant, a proxy for other traffic-related emissions, in accordance with a guideline from the World Health Organization (WHO). The fact that these data also provide a rough estimate of the impact of diesel on emissions is a handy side benefit, as diesel vehicles are the principal contributors to traffic-related NO_X emissions.[10] Passive sampling of this kind is useful for observing trends, but may provide higher values than continuous sampling, which is the method required to assess pollutants in accordance with New Zealand Environmental Standards for Air Quality (NESAQ). New Zealand's only standards for NO_2 exposure are for one-hour and 24-hour periods, whereas the results for *annual* exposure collected by passive sampling have to be assessed against a non-binding WHO guideline.[10]

An analysis by the NZTA of concentration levels of NO_2 recorded at roadside monitoring sites in the three largest cities over the years 2011–2019 shows a trend towards a reduction in mean and median levels of annual exposure over this period. This has been most marked over the last of these three years, a result attributed to improvements in vehicle design. However, three of the four sites that in 2016 exceeded the WHO annual guideline of >40 micrograms per cubic metre (μg/m^3) continued to do so through 2017–2019. Two of these sites were in Auckland and one in Hamilton.[52]

Local "hot spots" appear to be the areas most of concern for NO_2 concentrations. Rather than locations where people live, they are more likely to be places where there is stop–start driving, heavy traffic at rush hour and buildings that, due to their height, create a canyon effect, as on Lambton Quay in Wellington and Queen Street in Auckland. Poor air quality along Wellington's "Golden Mile" between Courtenay Place and Lambton Quay has been attributed to the combination of these physical features and the presence of a small number of old dirty diesels that have a disproportionate impact.[53] As well as places such as this, there are other urban sites in New Zealand where concentrations of NO_2 may not actually breach the WHO guideline for annual exposure, but that still approach or exceed the range that has been identified by the NZTA as a medium level of pollution (30–39.9 μg/m^3).[52]

More monitoring of similar hot spots would be desirable, especially with the trend for intensification of housing in the central parts of cities and the accompanying conversion of some office blocks for this purpose. For pedestrians and people waiting at bus stations in the centre of cities, especially those with respiratory conditions like asthma, exposure to pollutants at peak traffic times may be more significant than measures of annual concentrations. In central Wellington, however, one-hour exposures to NO_2 are within New Zealand's National Environmental Standards, which permit levels to exceed an average of 200 μg/m^3 no more than nine times per year. Acceptable limits today may, of course, be altered in the future. A recent multi-city and multi-country study of data from 398 cities and 27 countries or regions has found that exposure to NO_2 was associated with increased risks for mortality and morbidity even when levels were below regulatory guidelines. The authors suggest that considerable health benefits could follow from a strengthening of WHO limits the next time they are reviewed.[54]

Contributions of particular classes of vehicle to emissions of NO_x

The contribution of various types of vehicles to urban air pollution in New Zealand was explored by Bluett and various co-workers in a number of studies between 2003 and 2015. By using a remote sensory device (RSD), they were able to differentiate between the emissions of vehicles according to parameters such as age, type and whether they were diesel- or petrol-powered. The importance of the actual number of diesel-powered vehicles was illustrated by the 2015 study, which found that NO_x emissions from the more recent light-duty diesel vehicles had not improved significantly with new technology and, in fact, the negative pressure from a recent increase in the number of diesel light-duty vehicles was one factor leading to a plateau effect (stabilisation) in the volume of NO_x emissions at this time, after a period of decline.[55]

A recent and more comprehensive RSD study of the contribution to pollution of the gross emitters in the light vehicle fleet has helped to clarify the relevance of variables such as the age of these vehicles, which emission standard applies to them, their mileage, their fuel type and how long they are likely to stay in operation.[56] When the contribution of these gross emitters is contrasted with the median emissions of typical emitting vehicles in the rest of the fleet, it is estimated that their removal would result in a net reduction per year of 37,500 tonnes of carbon monoxide (CO), 2,500 tonnes of hydrocarbons (HC), 4,600 tonnes of nitrogen oxide (NO), 520 tonnes of nitrogen dioxide (NO2,) and 53 tonnes of particulate matter (PM). This work could, in future, provide guidelines for which older vehicles should be selected for scrappage, which is an area in which more monitoring would be desirable.[56]

Vehicle emissions prediction model

A broad assessment of the annual quantities of different categories of pollutants is provided in New Zealand by the vehicle emissions prediction model (VEPM) developed by the Auckland Council and the NZTA.[57] This can provide annual national emissions estimates in terms of tonnes per kilometre travelled. These are for a variety of pollutants—CO, volatile organic compounds (VOC), NO_x, CO_2, PM_{10} and $PM_{2.5}$. Emission factors are derived from a European model (COPERT). This model is used to identify trends in the country's emissions inventory, based on specifications of vehicles in the local fleet. Updates of the model since 2008 have moved beyond averaged speed estimates and fleet characteristics. Among the refinements are adjustments for changes in European emissions standards, the introduction of data on various vehicle types, including hybrids, alignment with Japanese emissions criteria and subtle aspects such as changes in road gradients.

This tool promises to be a useful source of estimates about emissions. In one example from research on the practicality of the model, real-world emissions from a small number of petrol and diesel vehicles were measured using a portable emissions monitoring system. The real-world emissions of most pollutants were up to eight times higher than those predicted by the VEPM, but the real-world NO_x results were comparable to those from Australia and Europe for similar vehicles.[58]

Monitoring of fine particle pollution

New Zealand currently has no national standards for $PM_{2.5}$ exposure. Work is now being done on developing standards for $PM_{2.5}$, which would align with WHO guidelines. The proposed standards would become the main regulatory tool for managing exposure to ambient particulate matter.[59] This will be a major step forward, as the absence of such standards is hard to justify, especially in the light of the vast literature about $PM_{2.5}$ in other countries and its impact on health. In the US, for example, standards for $PM_{2.5}$ exposure were first promulgated in 1997.[60] The availability of such data in the US facilitates the assessment of health and monetary benefits as the result of decreases in diesel exhaust emissions.[61]

At present, information about $PM_{2.5}$ depends on whether local authorities collect such data. Otherwise, findings must be inferred from the results of monitoring larger $PM_{1.0}$ particles. The most comprehensive dataset comes from Auckland, where monitoring of $PM_{2.5}$ has been focused on four particular sites—Queen Street, Khyber Pass, Takapuna and Penrose.[62] The

results for the years 2006–2013 demonstrate the seasonal nature of $PM_{2.5}$ exposure, particularly from biomass burning, as well as the variety of sources of these particles, which include sea spray. The Auckland data also enable the respective contributions from diesel and petrol emissions to be determined. At the Queen Street site, for example, diesel emissions accounted for 39% of total $PM_{2.5}$ and the contribution from petrol vehicles was 3%. The site-specific nature of such data is illustrated by the detail in the Auckland findings: ship emissions accounted for 5% of $PM_{2.5}$ at the Queen Street site near the port, whereas the comparative $PM_{2.5}$ contribution of diesel to petrol was lower at Takapuna than in the central city. The Auckland study has also been able to demonstrate long-term trends in $PM_{2.5}$, exposure, with a significant decline over the period 2006–2013. More recent data from the Takapuna site and another Auckland site show that this trend has continued and is traffic related.[10] The proposal to give a greater role to nationwide monitoring of $PM_{2.5}$ offers the opportunity to conduct further monitoring of the type carried out in Auckland and thus arrive at a better understanding of the role of diesel emissions in New Zealand.

ISSN 1175-8716

Competing interests:
Nil.

Author information:
John Horrocks: Independent Researcher, Hutt City.
Nick Wilson: Department of Public Health, University of Otago, Wellington.
Corresponding author:
Prof Nick Wilson, Department of Public Health, University of Otago, Wellington
nick.wilson@otago.ac.nz

URL:
www.nzma.org.nz/journal-articles/diesel-matters-accelerating-the-light-diesel-vehicle-end-game-in-aotearoa-new-zealand

REFERENCES

1. Global Burden of Disease Risk Factors Collaborators. Global burden of 87 risk factors in 204 countries and territories, 1990-2019: a systematic analysis for the Global Burden of Disease Study 2019. *Lancet* 2020;396:1223-49.
2. Vohra K, Vodonos A, Schwartz J, Marais EA, Sulprizio MP, Mickley LJ. Global mortality from outdoor fine particle pollution generated by fossil fuel combustion: Results from GEOS-Chem. *Environ Res* 2021;195:110754.
3. Ministry of Transport Te Manatū Waka. Annual Fleet Statistics. Wellington: Ministry of Transport, 2019. Available from: https://www.transport.govt.nz/assets/Uploads/Report/AnnualFleetStatistics.pdf
4. He Pou a Rangi: Climate Change Commission. 2021 Draft Advice for Consultation, p.108. Our advice and evidence. Wellington: He Pou a Rangi: Climate Change Commission, 2021. Available from: https://www.climatecommission.govt.nz/get-involved/our-advice-and-evidence/.
5. Radio New Zealand. Alistair Woodward: The rise of the urban light truck. Radio New Zealand 2021;(19 June). Available from: https://www.rnz.co.nz/national/programmes/saturday/audio/2018800439/alistair-woodward-the-rise-of-the-urban-light-truck.
6. Ford New Zealand. NZ's Favourite Workmate. (Accessed 6 March, 2021). Available from: https://www.ford.co.nz/commercial/ranger/
7. Motor Industry Association. Vehicle Sales (Accessed 3 March, 2021). Available from: https://www.mia.org.nz/Sales-Data/Vehicle-Sales
8. Horrocks J, Wilson N. "Beasts"-New Zealand's utility vehicles: their climate change emissions and macho marketing. *N Z Med J* 2019;132:90-99.
9. European Union. Urban Access Regulations in Europe. (Accessed 12 March, 2021). Available from: https://urbanaccessregulations.eu/.
10. Ministry for the Environment and Statistics NZ. Our Air 2018. Ministry for the Environment and Statistics NZ, 2018. Available from: https://environment.govt.nz/publications/our-air-2018/.
11. International Council on Clean Transportation. Vehicle NOx emissions: The basics (10 October 2017). Available from: https://theicct.org/cards/stack/vehicle-nox-emissions-basics
12. Mitchell T. Traffic-related air quality monitoring in the Wellington Region 2016/17. Greater Wellington Regional Council, 2017. http://www.gwrc.govt.nz/assets/council-publications/Traffic-related-air-quality-indicator-201617.pdf
13. International Agency for Research on Cancer (IARC). IARC: Diesel engine exhaust carcinogenic. Press release No. 213. (12 June 2012). Available from: https://www.iarc.who.int/wp-content/uploads/2018/07/pr213_E.pdf.
14. Dockery DW, Pope CA, 3rd, Xu X, Spengler JD, Ware JH, Fay ME, Ferris BG, Jr., Speizer FE. An association between air pollution and mortality in six U.S. cities. *N Engl J Med* 1993;329:1753-9.
15. Di Q, Wang Y, Zanobetti A, Wang Y, Koutrakis P, Choirat C, Dominici F, Schwartz JD. Air pollution and mortality in the Medicare population. *N Engl J Med* 2017;376:2513-22.
16. Hales S, Blakely T, Woodward A. Air pollution and mortality in New Zealand: cohort study. *J Epidemiol Community Health* 2012;66:468-73.
17. Hales S, Atkinson J, Metcalfe J, Kuschel G, Woodward A. Long term exposure to air pollution, mortality and morbidity in New Zealand: Cohort study. *Sci Total Environ* 2021;801:149660.
18. Newbury J, Stewart R, Fisher H, Beevers S, Dajnak

D, Broadbent M, Pritchard M, Shiode N, Heslin M, Hammoud R, Hotopf M, Hatch S, Mudway I, Bakolis I. Association between air pollution exposure and mental health service use among individuals with first presentations of psychotic and mood disorders: retrospective cohort study *Br J Psychiatry* 2021;doi: 10.1192/bjp.2021.119.

19. New Zealand Government. Rightcar. (Accessed 12 March, 2021). Available from: https://rightcar.govt.nz/carbon-emissions.
20. New Zealand Transport Agency Waka Kotahi. Exhaust: Table 11-2-5 Approved exhaust emission standards for new diesel-powered vehicles. Available from: https://vehicleinspection.nzta.govt.nz/virms/entry-certification/i-and-c/exhaust/exhaust-emissions#up.
21. UK Automobile Association. Euro Emissions Standards: Limits to improve air quality and health (updated 11 December 2017). Available from: https://www.theaa.com/driving-advice/fuels-environment/euro-emissions-standards
22. German Environment Agency. Nitrogen pollution from diesel-fuelled cars even higher than suspected. (Press release 25 April 2017). Umweltbundesamt. Available from: https://www.umweltbundesamt.de/en/press/pressinformation/nitrogen-pollution-from-diesel-fuelled-cars-even.
23. Anenberg SC, Miller J, Minjares R, Du L, Henze DK, Lacey F, Malley CS, Emberson L, Franco V, Klimont Z, Heyes C. Impacts and mitigation of excess diesel-related NOx emissions in 11 major vehicle markets. *Nature* 2017;545:467-71.
24. Autotalk. Ministry admits admissions approach was incorrect. Autotalk 2021;(16 June). Available from: https://autotalk.co.nz/news/ministry-admits-emissions-approach-was-incorrect
25. Baldino C, Tietge U, Muncrief R, Bernard Y, Mock P. Road Tested. Comparative Overview of Real-World Versus Type Approval of NOx and CO2 Emissions from Diesel Cars in Europe. International Council for Clean Transportation. White Paper (September 2017). https://theicct.org/sites/default/files/publications/ICCT_RoadTested_201709.pdf.
26. Hotton R. Volkswagen. The scandal explained. BBC News (10 December 2015). https://www.bbc.com/news/business-34324772
27. Waka Kotahi New Zealand Transport Agency. Requirements for urban buses in New Zealand for consistent urban bus quality (updated March 2021). Waka Kotahi New Zealand Transport Agency. Available from: https://nzta.govt.nz/assets/resources/requirements-for-urban-buses/docs/requirements-for-urban-buses-2021.pdf.
28. US Environmental Protection Agency. Tampered Diesel Pickup Trucks: A Review of Aggregated Evidence from EPA Civil Enforcement Investigations. US Environmental Protection Agency (September 2020). Available from: https://int.nyt.com/data/documenttools/epa-on-tampered-diesel-pickups-11-20/6d70536b06182ad2/full.pdf.
29. Bernton H. Washington state diesel truck shop accused of tampering with hundreds of pickups to thwart emission controls. Seattle Times 2021;(13 May). https://www.seattletimes.com/seattle-news/environment/washington-state-diesel-truck-shop-accused-of-tampering-with-hundreds-of-pickups-to-thwart-emission-controls/.
30. Greater Wellington Regional Council. Improved quality of public transport. p.1. Greater Wellington Regional Council, 2021. Available from: http://www.gw.govt.nz/improved-quality-of-public-transport/
31. He Pou a Rangi Climate Change Commission. 2021 Draft Advice for Consultation. NZ Government, 2021. Available from: https://ccc-production-media.s3.ap-southeast-2.amazonaws.com/public/evidence/advice-report-DRAFT-1ST-FEB/ADVICE/CCC-ADVICE-TO-GOVT-31-JAN-2021-pdf.pdf.
32. Ministry of Transport. Hīkina te Kohupara – Kia mauri ora ai te iwi Transport Emissions: Pathways to Net Zero by 2050 (Green Paper). Wellington, Ministry of Transport, 2021. Available from: https://www.transport.govt.nz/assets/Uploads/Discussion/DiscussiondocumentHikinateKohuparaKiamaurioraaiteiwiTransportEmissionsPathwaystoNetZeroby2050.pdf. 2021.
33. Ministry of Transport. Moving the light vehicle fleet to low-emissions: discussion paper on a Clean Car Standard and Clean Car Discount (9 July, 2019). Available from: https://www.transport.govt.nz/assets/Import/Uploads/Our-Work/Documents/11de862c28/LEV-consultation-document-final.pdf.
34. Waka Kotahi New Zealand

Transport Agency. Clean Car Programme Overview (June 2021). Available from: https://www.nzta.govt.nz/vehicles/clean-car-programme/overview/.

35. Satherley D. Gas guzzling fees could be twenty times higher – Green MP Julie Anne Genter. Newshub 2021;(19 June). https://www.newshub.co.nz/home/politics/2021/06/gaz-guzzling-vehicle-fees-could-be-20-times-higher-green-mp-julie-anne-genter.html.
36. Ministry of Transport. Moving the light vehicle fleet to low emissions: discussion paper on a Clean Car Standard and Clean Car Discount. Ministry of Transport, 2019. Available from: https://www.transport.govt.nz/assets/Uploads/Discussion/LEV-consultation-document-final.pdf.
37. Motor Industry Association. Submission to Climate Change Commission 2021 draft advice for consultation (28 March 2021). Lower Hutt: Motor Industry Association, 2021. Available from: https://www.mia.org.nz/Portals/0/MIA%20submission%20on%20Climate%20action%20for%20Aotearoa%20New%20Zealand%20-%2028%20March%202021.pdf?ver=MuERbULBFJC-gwBqxgU3R_g%3D%3D.
38. US Environmental Protection Agency. Making School Buses Cleaner (Updated 6 August 2020). Available from: https://www.epa.gov/dera/making-school-buses-cleaner
39. Ministry of Transport. A vehicle scrappage trial for Wellington and Christchurch: May 2009. Ministry of Transport. Available from: https://www.transport.govt.nz/assets/Uploads/Report/Scrappage-Report-FINAL.pdf
40. Custard B. Scrappage schemes the complete guide. Car Buyer 2021;(3 February). https://www.carbuyer.co.uk/tips-and-advice/156243/2021-scrappage-schemes-the-complete-guide.
41. Ford New Zealand. You're Going to Need a Bigger Garage. New Zealand Autocar (2018, December), p2.
42. He Pou a Rangi–the Climate Change Commission. Chapter 17: The direction of policy for Aotearoa. Climate Change Commission, 2021. Available from: https://ccc-production-media.s3.ap-southeast-2.amazonaws.com/public/evidence/advice-report-DRAFT-1ST-FEB/Evidence-CH-17-direction-of-policy-for-Aotearoa-21-Jan-2021.pdf.
43. New Zealand Productivity Commission. Low-emissions economy: Final report. NZ Productivity Commission, 2018. Available from: https://www.productivity.govt.nz/assets/Documents/4e01d69a83/Productivity-Commission_Low-emissions-economy_Final-Report.pdf.
44. Trevett C. The 'feebate'–Govt can confirm rebates for buyers of electric cars, but petrol car buyers will cop it. NZ Herald. 2021;(13 June). https://www.nzherald.co.nz/nz/the-feebate-govt-confirms-rebates-for-buyers-of-electric-cars-but-petrol-car-buyers-will-cop-it/TEJ3V5CF72YFTT5NPQTOW-J3AAE/.
45. Molloy S. Bill Shorten is killing off the ute, according to critics. News.com.au. 2019;(10 April). https://www.news.com.au/national/federal-election/bill-shorten-is-killing-off-the-ute-according-to-critics/news-story/e637de638a169d-03114036e9f488702d.
46. Crabb A. The secret life of utes: How Australia's 'blokey' car has a grip on politicians. ABC News 2019;(10 April). https://www.abc.net.au/news/2019-04-09/utes-electric-cars-and-politics/10983298.
47. Cooke H. 'Shameful' delay on Nats' misleading ad. New Zealand Herald 2020;(12 February), p. 17.
48. Reuters Staff. Fossil fuel-based vehicle bans across the world. Reuters 2020;(18 November). https://www.reuters.com/article/climate-change-britain-factbox-idINKBN27Y19F.
49. New Zealand Government. Land Transport (Road Use) Rule 2004. Emission or smoke vapour from motor vehicles. 7.5 (3). NZ Government. (Reprint 1 May 2021). Available from: https://www.legislation.govt.nz/regulation/public/2004/0427/latest/whole.html#DLM303623.
50. Green J. Does carbon pricing reduce emissions? A review of ex-post analyses. *Environ Res Lett* 2021;16:043004.
51. Carattini S, Kallbekken S, Orlov A. How to win public support for a global carbon tax. *Nature* 2019;565:289-91.
52. Waka Kotahi New Zealand Transport Authority. Ambient Air Quality (Nitrogen Dioxide) Monitoring Programme. Annual Report 2007-2019. Waka Kotahi New Zealand Transport Authority, 2020. Available from: https://www.nzta.govt.nz/assets/resources/air-quality-monitoring/no2-monitoring-network-site-metadata-report-2007-2019.pdf.
53. Radio New Zealand/Stuff. Diesel vehicles are

keeping Wellington from world-beating air quality – NIWA (29 December 2019). Radio New Zealand/Stuff. https://www.stuff.co.nz/dominion-post/news/wellington/118509781/diesel-vehicles-keeping-wellington-from-world-beating-air-quality--niwa.

54. Meng X, Liu C, Chen R, Sera F, Vicedo-Cabrera AM, Milojevic A, Guo Y, Tong S, Coelho M, Saldiva PHN, Lavigne E, Correa PM, Ortega NV, Osorio S, Garcia, Kysely J, Urban A, Orru H, Maasikmets M, Jaakkola JJK, Ryti N, Huber V, Schneider A, Katsouyanni K, Analitis A, Hashizume M, Honda Y, Ng CFS, Nunes B, Teixeira JP, Holobaca IH, Fratianni S, Kim H, Tobias A, Iniguez C, Forsberg B, Astrom C, Ragettli MS, Guo YL, Pan SC, Li S, Bell ML, Zanobetti A, Schwartz J, Wu T, Gasparrini A, Kan H. Short term associations of ambient nitrogen dioxide with daily total, cardiovascular, and respiratory mortality: multilocation analysis in 398 cities. *BMJ* 2021;372:n534.

55. Bluett J, Aguiar M, Smit R. Understanding trends in roadside air quality. NZ Transport Agency Research Report 596. 2016. https://nzta.govt.nz/assets/resources/research/reports/596/596.pdf

56. Waka Kotahi New Zealand Transport Agency. Assessing the Impact of Gross Emitting Vehicles. 2021. Pattle Delamore Partners Ltd. p.33. Available from: https://www.nzta.govt.nz/assets/Highways-Information-Portal/Technical-disciplines/Air-and-climate/Monitoring/Remote-sensing/assessing-the-impact-of-gross-emitting-vehicles-pdp-202007.pdf.

57. Waka Kotahi NZ Transport Agency. Vehicle Emissions Prediction Model. Waka Kotahi NZ Transport Agency, 2021. Available from: https://www.nzta.govt.nz/roads-and-rail/highways-information-portal/technical-disciplines/air-quality-climate/planning-and-assessment/vehicle-emissions-prediction-model/.

58. Kuschel G, Metcalfe J. NZTA Research Report 658. Testing New Zealand vehicles to measure real world fuel use and exhaust emissions. NZ Transport Agency, 2019. https://www.nzta.govt.nz/resources/research/reports/658/.

59. Ministry for the Environment. Proposed amendments to the National Environmental Standards for Air Quality: particulate matter and mercury emissions–consultation document. Wellington: Ministry for the Environment, 2020. Available from: https://environment.govt.nz/assets/Publications/Files/proposed-amendments-to-the-national-environmental-standards-for-air-quality-consultation-document_0.pdf.

60. Esworthy R. CRS Report for Congress. Updated January 10 2005. Particulate Matter Air Quality Standards: Background and Current Developments. https://www.everycrsreport.com/files/20050110_RL31531_22b3ea88131ddb75d084677154c8125abee568e0.pdf.

61. US Environmental Protection Agency. Diesel Emissions Quantifier (version 8.4; 21 December 2020). Available from: https://cfpub.epa.gov/quantifier

62. GNS Science. Source apportionment and trend analysis of air particulate matter in the Auckland Region. July 2017. Technical Report TR2017/001. Prepared for Auckland Council by GNS Science.