Ministry of Transport
TE MANATŪ WAKA

Vehicle Purchase Feebate Scheme
Preliminary Cost- Benefit Analysis

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Preface

This report documents a preliminary cost benefit analysis on the introduction of a vehicle purchase feebate scheme on the importation of light vehicles. Vehicle buyers who purchase emissions-intensive vehicles prepay a fee in recognition of the increased environmental and economic costs they are imposing on the wider society. These fees are then used to reward vehicle buyers who opt to buy vehicles with zero or very low carbon emissions. This is one of the policy options that aims to reduce greenhouse gas emissions in road transport and to contribute towards New Zealand's efforts to transition towards a net zero carbon economy.

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Acknowledgement

This preliminary Cost-Benefit Analysis has been prepared by the Domain Strategy, Economics and Evaluation team at the Ministry of Transport.

The Domain Strategy, Economics and Evaluation team operates within the Regulatory and Data Group of the Ministry of Transport. The team supports the Ministry's policy teams by providing the evidence base at each stage of the policy development.

The team is responsible for:

- Developing the Transport Evidence Base and the Transport Knowledge Hub which connects people from across the wider transport sector and promotes the sharing of transport data, evidence, knowledge, research, information, capabilities, and ideas.
- Providing economic input on business cases, funding requests, competition issues and specific projects such as value capture, natural disasters, and the social impacts on environment and health.
- Providing the evaluation function for the Ministry, including designing evaluation frameworks, developing performance metrics and indicators, and designing, conducting and procuring evaluations.

Important qualifications

Due to the lack of information and/or time and resources, this cost benefit analysis does not include the following items:

- Possible changes to consumer preferences for specific vehicle types.
- Supply-side impacts on the different vehicle types or models, including electric and hybrid vehicles, available in the New Zealand market.
- Road safety impacts associated with changes in vehicle mixes and technologies.
- Health impacts from reduction in air pollution and noise pollution due to lower fuel consumption or abatement technologies and accelerated take-up of electric vehicles.
- Changes in vehicle maintenance costs due to changes in vehicle technology, engine size and vehicle type.
- Any wider economic or distributional impacts by region or by income cohort.

Where possible and appropriate, a sensitivity analysis has been carried out to understand the materiality of varying some of the key inputs on the model results.

An earlier draft of this Cost-Benefit Analysis has been peer reviewed by the Schiff Consulting.

Disclaimer

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GLOSSARY OF TERMS AND ABBREVIATIONS

BEV	Battery Electric Vehicle
BCR	Benefit-cost ratio
CBA	Cost benefit analysis
CAPEX	Capital Expenditure
CO_2	Carbon Dioxide
CO_2 emission level	Level of CO^2 emitted
CO_2 emission target	Targeted value of CO_2 emission level
EEM	Economic Evaluation Manual
EPA	Environment Protection Agency
ETS	Emissions Trading Scheme
EV	Electric Vehicle
FIRR	Financial Internal Rate of Return
GHG	Greenhouse Gas
GVM	Gross Vehicle Mass
GST	Goods and services tax
ICCT	International Council for Clean Transportation
ICE	Internal Combustion Engine
LCV	Light Commercial Vehicles
MAC	Marginal Abatement Cost
MVR	Motor Vehicle Register
NEDC	New European Driving Cycle
NPV	Net Present Value
NZTA	New Zealand Transport Agency
OPEX	Operational Expenditure
PV	Present value
SUV	Sports Utility Vehicle
UNECE	United Nations Economic Commission for Europe
UNFCCC	United Nations Framework Convention on Climate Change
VFEM	Vehicle Fleet Emissions Model
VFES	Vehicle Fuel Efficiency standard
VKT	Vehicle Kilometres Travelled
WLTP	World Harmonised Light Vehicles Test Procedure

1. *Executive Summary*

The proposed introduction of a vehicle purchase feebate scheme in 2020 aims to accelerate the reduction in average CO_2 emissions of vehicle imports. This scheme is expected to result in a net benefit ranging from $111 million - $821 million (midpoint $413 million) to private vehicle users and to the wider society. Most of the benefits (93.3%) are gained by private vehicle users from fuel savings with the remaining benefits (6.7%) accrued to the wider society through reductions in greenhouse gas (GHG) emissions.

This scheme is expected to induce behavioural changes in consumers' purchasing decisions in favour of low emission vehicles including electric and hybrid vehicles. Without any direct intervention, the current (2017) average emissions of 178 gCO_2/km will only decline to 158 gCO_2/km by 2025 and will reach 105 gCO_2/km by around 2039.

The major share of the costs (85.5%) is incurred by vehicle buyers through changes in the price of their preferred vehicle as a result of the fee levied on high-emissions vehicles. However, the extent of this welfare loss will depend on a number of factors, including consumers' response to vehicle price changes and how importers will alter their fleet profile following changes in consumers' purchasing preferences. The remaining costs (14.5%) are expected to be incurred by the Government and its agencies for the implementation of this scheme. The total costs from implementing the feebate scheme are estimated to range between $185 million - $336 million (midpoint $258 million) in present value over its lifetime.

The implementation of a feebate scheme will result in substantial benefits that offset the aforementioned costs. Fuel cost savings account for a major share (93.3%) of total benefits and are gained by private vehicle users when they purchase a vehicle that is more fuel efficient. The monetary benefits of reducing greenhouse gases account for a small share of total benefits (6.7%). The total benefits from the feebate scheme are estimated to range from $347 million - $1,111 million (midpoint 671 million) in present value over its lifetime.

The net present value (NPV) of the feebate scheme is estimated to range from $111 million - $821 million (midpoint $413 million) over its lifetime and is expected to reduce GHG emissions ranging between 1 million - 2.3 million tonnes of CO_2 (midpoint 1.6 million). Excluding fixed costs, the net social benefit from abating an additional tonne of CO_2 is estimated to range from $90 - $423 (midpoint $266) with the proposed feebate scheme.

A Monte Carlo simulation was carried out to test the viability of the feebate scheme by changing a number of parameters independently or jointly. The estimated NPV ranges from $111 million to $821 million and the corresponding estimated BCR ranges from 1.4 and 4.2 at the 90% confidence interval. Table 1 below summarises the main economic indicators and their range of uncertainty obtained from the sensitivity analysis.

Table 1: Summary of the costs and benefits of implementing feebate regime from 2020 to 2025

All dollar estimates are expressed in present value at a 6% discount rate and cover years 2020 to 2041	**Mid-Range**	**Minimum**	**Maximum**	**90% Confidence Interval**	
Benefits:					
Fuel Savings ($ million)	627	172	1805	328	1050
Reduction in GHG emission ($ million)	44	10	105	19	60
Costs:					
Welfare loss to vehicle buyers ($ million)	221	113	384	154	292
Implementation Costs to Government ($ million)	37	26	52	31	44
Economic Viability Indicators:					
Net Present Value ($ million)	413	-82	1513	111	821
Benefit-Cost Ratio	2.60	0.76	7.05	1.44	4.22
Marginal Abatement Cost ($/t$CO_2$)[1]	-266	-569	79	-423	-90

[1] A MAC is the cost of eliminating an additional unit of emissions. A MAC curve represents the relationship between the quantity of abated emissions and the [incremental] price of CO2 through the implementation of abatement measures

2. Background

2.1. Overview

This report provides a preliminary assessment of the benefits and costs accruing to the society from the introduction of a vehicle purchase feebate scheme (or the feebate scheme) on light vehicles entering the New Zealand fleet. This intervention is expected to shift consumer demand in favour of vehicles that have lower average CO_2 emissions and thus accelerate the observed downward trend in the average CO_2 emissions of New Zealand's light vehicle fleet. The assessment is based on implementation of the feebate scheme on its own, without combining other additional policy interventions current being considered. Such an exercise will be conducted separately and documented in a separate report.

Feebates attempt to induce vehicle buyers to bear the social cost (in the form of a fee), or receive the social benefit (in the form of a rebate) of their vehicle purchase choices on the environment. An emissions threshold is chosen in grams of CO_2 per kilometre (gCO_2/km) and purchasers of vehicles that emit less than the threshold will receive a rebate while purchasers of vehicles that emit more than the threshold will be levied a fee.

The feebate will be applied on the purchase price of passenger and commercial vehicles that are first registered in New Zealand in 2020 and which have a gross vehicle mass (GVM) of 3.5 tonnes or less. Therefore, this scheme will encompass passenger cars, sports utility vehicles (SUVs), people movers, Utes and light commercial vehicles (LCVs) including pickups and mini buses. It will also be applied to both new and used vehicles upon first registration in New Zealand, albeit at different feebate rates.

The feebate will be applied according to the vehicle's CO_2 emissions rating. This rating is based on the New European Driving Cycle (NEDC)[2] test or equivalent if the model is non-European. Note that the World Harmonised Light Vehicles Test Procedure (WLTP) is expected to be adopted in European and UN Regulations by 2020, and hence, the feebate rates may need to be redefined, accordingly.

2.2. The Policy Problem and Objective

Under the Paris Agreement on Climate Change, New Zealand committed to reduce greenhouse gas (GHG) emissions to 30 percent below 2005 levels by 2030 [1]. To ensure that New Zealand joins with international leading countries to combat climate change, the Government has set a goal for New Zealand to be a net zero emissions economy by 2050 [2]. Transport accounts for 18 percent of New Zealand's GHG emissions, with light vehicles contributing to around two-third [3].

The Ministry of Transport is currently investigating a range of policy interventions to supplement existing policy settings, such as emissions trading scheme and the Electric Vehicles (EVs) programme implemented in 2016, to help reduce New Zealand's GHG emissions from light vehicles. The policy options range from awareness-raising programmes to incentive-based or performance-based measures to increase the uptake of more fuel efficient light vehicles entering the New Zealand fleet. This report focuses only on the implementation of a feebate scheme.

[2] The NEDC is a test driving cycle specified in the United Nations Economic Commission for Europe (UNECE) regulations which sets out procedures for determining fuel consumption and CO_2 emissions from light vehicles. It attempts to represent typical on-road driving conditions better than previous regulatory test cycles.

2.3. Description of Costs & Benefits

The costs of the feebate scheme to vehicle buyers include the following:

- Compliance cost to vehicle buyers who would choose to purchase their preferred vehicle at a higher price;
- Welfare loss to vehicle buyers who would choose to purchase vehicles that are less emission-intensive by trading-off with other vehicle features (at the same price).

This analysis also includes the costs incurred by the Government, mainly the New Zealand Transport Agency (NZTA), which would be responsible for the implementation of the feebate scheme. The initial capital cost covers the development of automated submission and payment processes using online as the preferred channel and to undertake the required changes in the Motor Vehicle Register (MVR) software. The annual operational costs cover handling the fee collection and rebate distribution processes, administration of this scheme and awareness-raising campaigns. These costs have been estimated by NZTA.

The monetary benefits are those gained by vehicle buyers in the form of fuel savings[3] and by the wider society through lower greenhouse gas emissions. Due to a lack of information, this report excludes any potential health benefits from reductions in the concentrations of air pollution and noise pollution from the purchase of more fuel efficient conventional vehicle and the accelerated uptake of EVs. There could also be positive impacts on the security of energy supply and New Zealand's trade balance. However, the size of these impacts is likely to be small. Therefore, the actual benefits from the introduction of a feebate scheme could be marginally higher than the figures shown in this report.

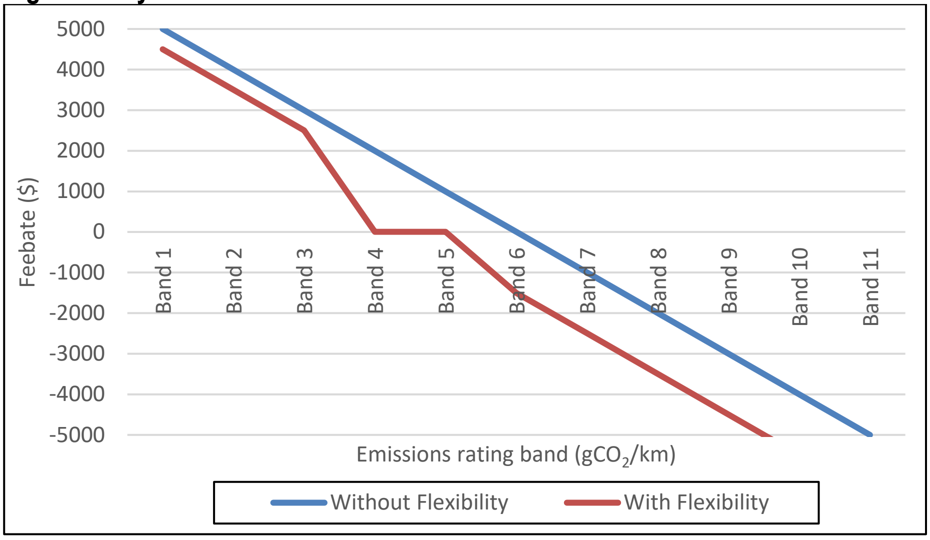
2.4. Determining the Feebate Schedule

The assumed starting year (i.e. Year 1) of the feebate scheme for the purposes of this cost-benefit analysis is 2020 and will run until 2025 (both years inclusive). The applicable fee or rebate rate will depend on two main factors, namely: (i) the average CO_2 emissions of the vehicle; and (ii) the year when the vehicle is first registered in New Zealand.

The feebate rates can be set in numerous ways to account for different CO_2 emission bands and at different points in time. Similarly, the pivot point that determines which vehicles will attract a rebate and which ones will be levied a fee can also be set differently. It is therefore important that the feebate rates and the pivot point are set in a way that will have a material impact on consumer demand. Figure 1 below illustrates two stylised feebate schedules in relation to different CO_2 emission rating bands, one with flexibility (for emission bands 4 and 5) and the other without any flexibility.

[3] More precisely, the private user will save on the fuel cost that is avoided due to the purchase (and use) of a vehicle that has a better fuel consumption rating.

Figure 1: Stylised Feebate Schedule



The assumed pivot point for this cost-benefit analysis is 105 grams of CO_2 emitted per kilometre travelled (gCO_2/km). This means that those vehicles that have an average CO_2 emissions that is equal to, or lower than, 105 gCO_2/km will receive a rebate when first registered between 2020 and 2025. At present, EVs, hybrid vehicles and some efficient fossil-fuel powered vehicles (i.e. internal combustion engine or ICE vehicles) fall within this CO_2 band. Conversely, vehicles that have a CO_2 rating that is greater than 105 gCO_2/km and which are first registered in 2020 or later, will be levied a fee.

In order to provide some flexibility to vehicle buyers, the CBA assumed vehicles that have average emissions of 106-120 gCO_2/km will not subject to a fee, and vehicles that have an average emissions of 121-130 gCO_2/km will be subject to a fee in the last year (2025) of the intervention.

If the feebate scheme were to be advanced, it is likely that a higher pivot point, for example 135 grams, would be established when the scheme is first introduced. It could also have a wide "zero band" where vehicles are over the pivot point but attract no fees. This could apply to vehicles that have lower emissions than today's average vehicle. This is to allow consumers time to adjust their vehicle preferences without being penalised. It would also focus the fees on the highest emitting vehicles.

The feebate schedules applicable to new and used vehicles are shown in Table 8 in Annex 1. These schedules were based on a combination of fees and rebates that comply with a number of pre-set boundaries (as further detailed below) and which translate to the highest Net Present Value over the lifetime of the scheme.

One of the key principles for determining the levels of fee and rebate is to apply a higher fee for vehicles with higher emissions beyond the pivot point and to provide a higher reward (i.e. rebate) for vehicles with lower emissions level. In addition, a number of additional boundaries have been set to obtain fee and rebate rates that are not unrealistically low or unacceptably high. These boundaries are:

- The fee or rebate does not exceed $5,000 per new vehicle and $1,000 per used vehicle.
- The fee or rebate is not less than 2% of the average projected price of the vehicle.
- The feebates are kept fixed for a three-year period, except for vehicles with an emission rating equal to or less than 49 gCO_2/km, in which case the rebate is reduced annually in line with the projected decrease in the price of such vehicles.
- Fees will increase at a decreasing rate over time whereas rebates will decrease at an increasing rate over time.

Given the uncertainty in predicting consumer behaviour as a result of the feebates, the rates may be reviewed after the implementation of the scheme to ensure the levels of fee and rebate are set at the right level to encourage a shift in vehicle purchasing decisions to accelerate the uptake of low emission vehicles over time.

3. *The Baseline Scenario*

3.1. Baseline Description

To assess the impact of the feebate scheme, it is necessary to define the counterfactual or the baseline scenario for comparison purposes. In this scenario, it is assumed that there will be no additional policy intervention apart from those already implemented (such as the emission trading scheme) to alter the predicted trend in the average CO_2 emission level of the light vehicle imports. The average CO_2 emission level would reflect the changes in the number of imports by vehicle type and the level of travel[4] by vehicle age and other characteristics. The policy intervention will run from 2020 to 2025 but the analysis includes costs and benefits up to 2041 to include the benefits over the economic life of a new vehicle (17 years) purchased in the last year of the scheme (2025).

3.2. Baseline Methodological Approach

The analysis has utilised information extracted from the Motor Vehicle Register (MVR) [4] on the number of vehicles imported in 2017. New and used imports are analysed separately with vehicles categorised by CO_2 emissions band in each case. The classification of these imports into the various CO_2 emissions bands was based on the quarterly vehicle fleet statistics of 2017 published by the Ministry of Transport [5].

Projections of new and used vehicle imports by CO_2 emission band were based on the growth rates observed in the Vehicle Fleet Emissions Model (VFEM) **'Slow EV Uptake'** scenario modelled by the Ministry of Transport [6]. The VFEM projects the composition of the future vehicle fleet including the total vehicle kilometres travelled, the energy used (fuel and electricity) and the greenhouse gas emissions based on assumed economic, demographic and technological trends, including the likely EV uptake and fuel efficiency improvements in conventional vehicles.

In the 'Slow EV Uptake' scenario, the annual growth rates in vehicle registrations differ depending on the powertrain. For EVs, the growth rate is projected to be much faster than that of fossil fuel powered (or internal combustion engine or ICE) vehicles over the policy period. Table 2 below shows the projected annual growth rates of vehicle registrations by fuel type while Figure 2 shows the projected vehicle imports under different CO_2 emissions bands for the baseline scenario.

Table 2: Estimated annual growth rates in vehicle registrations – baseline scenario

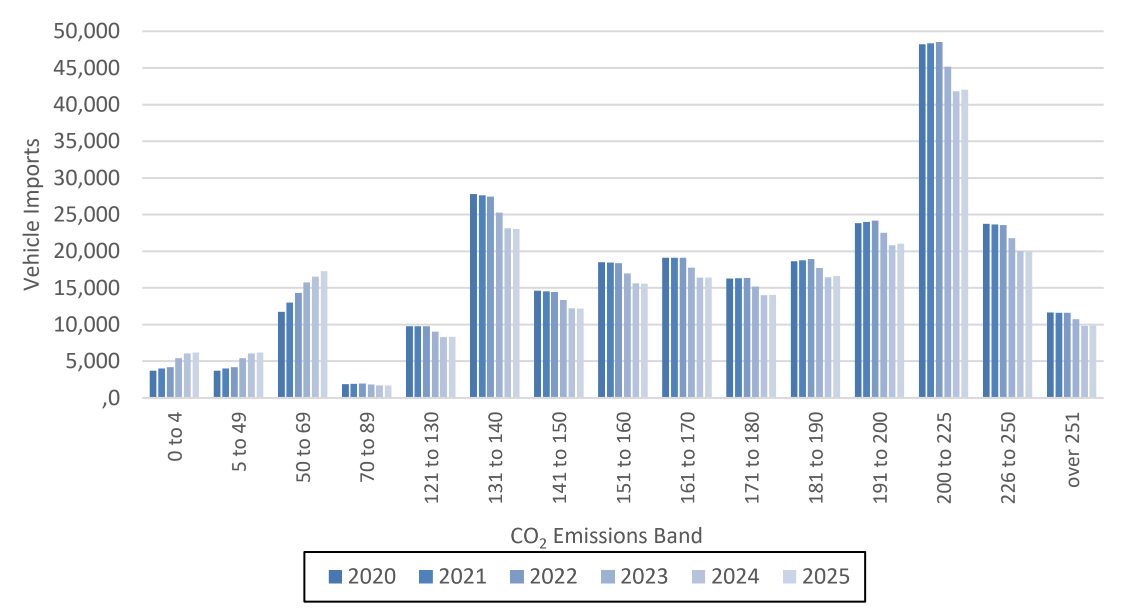
	Diesel	Petrol	Electric	Plug-in Diesel^	Plug-in Petrol^	Hybrid Diesel^	Hybrid Petrol^
2017 (Actual)	9%	-1%	77%	0%	21%	-100%	52%
2018	-4%	-4%	58%	500%	137%	0%	27%
2019	-5%	-5%	63%	78%	52%	0%	20%
2020	0%	-2%	43%	153%	123%	0%	20%
2021	1%	0%	10%	65%	7%	0%	11%
2022	0%	0%	10%	41%	7%	106%	10%
2023	-4%	-8%	12%	21%	9%	42%	10%
2024	-5%	-9%	14%	15%	15%	26%	5%
2025	0%	1%	10%	20%	12%	28%	4%
2026	1%	-2%	13%	22%	14%	22%	17%
2027	1%	-2%	13%	19%	13%	19%	16%
2028	0%	-4%	11%	15%	11%	15%	12%

[4] These travel needs are reflected in the annual average vehicle kilometres travelled. These are, in turn, influenced by the driving preferences of vehicle users, the average age of the vehicle and the fuel retail price.

	Diesel	Petrol	Electric	Plug-in Diesel^	Plug-in Petrol^	Hybrid Diesel^	Hybrid Petrol^
2029	0%	-5%	10%	13%	10%	13%	10%
2030	1%	-3%	10%	13%	10%	13%	11%
2031	-1%	-2%	8%	7%	0%	12%	10%
2032	-1%	-2%	8%	6%	0%	10%	9%
2033	-3%	-4%	7%	5%	-1%	8%	6%
2034	-3%	-4%	7%	4%	-2%	8%	5%
2035	-2%	-3%	7%	5%	-1%	8%	7%
2036	-2%	-1%	5%	13%	2%	8%	3%
2037	-2%	-1%	5%	12%	2%	7%	2%
2038	-1%	-1%	5%	12%	2%	8%	2%
2039	-2%	-2%	5%	11%	2%	8%	2%
2040	-3%	-2%	4%	9%	1%	6%	2%

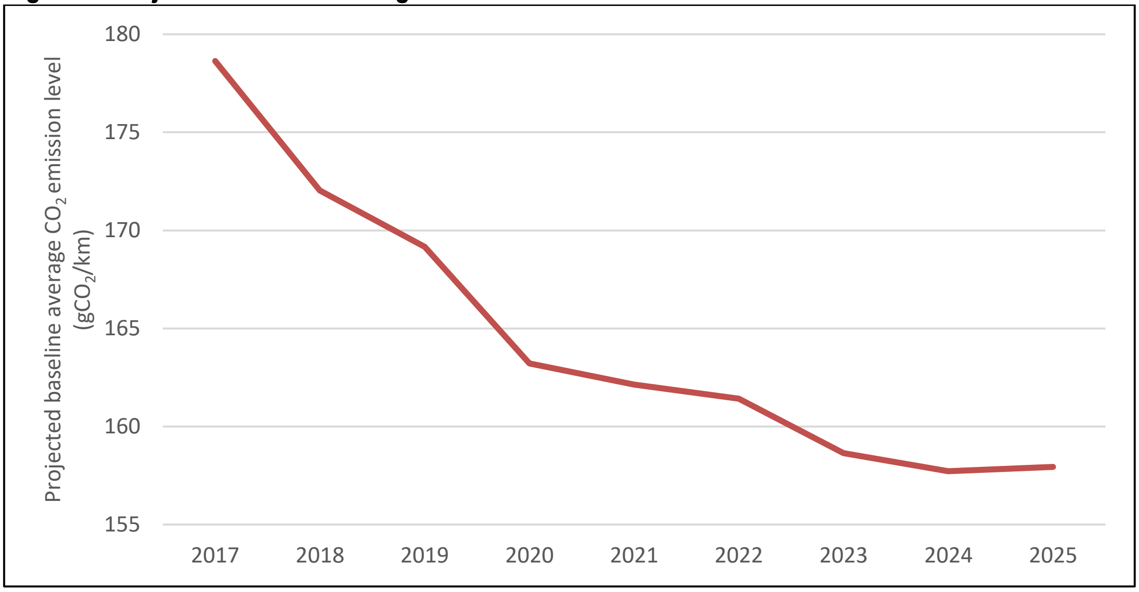
^ the large percentage changes for plug-in and hybrid vehicles reflect very few changes in the number of vehicles in absolute terms

Figure 2: Projected vehicle imports under different emission bands – baseline scenario



The projected increase in EVs in the baseline scenario will only marginally improve the average CO_2 emission level of the fleet of the new and used vehicle imports from the current (2017) average of 178g CO_2/km to 158g CO_2/km by 2025. An emissions level of 105g CO_2/km for the vehicle fleet entering New Zealand will only be attained by around 2039 [6]. The policy intervention intends to accelerate this improvement. Figure 3 shows the projected average CO_2 emission level in the baseline.

Figure 3: Projected baseline average CO_2 emission level



The baseline scenario rests on a number of assumptions and conditions that are necessary to model robust projections, namely:

- Consumer preferences between used and new vehicles will be at the ratio indicated in the VFEM projections. In 2017, the share of new vehicles was 52% of total imports [5].
- The average economic life of a brand new vehicle is 17 years and that of a used vehicles is 7 years (i.e. the average age for a used import is 10 years when it enters the fleet) [7].
- Historic data on the average annual VKT are obtained from the Vehicle Fleet Statistics [5] while the projections of these figures are based on the VFEM 'Slow EV Uptake' scenario [6]. An annual reduction of 4% in the average annual VKT is then applied to account for reducing travel as the vehicle ages [7].
- The proportion of total trips between different travel modes is unchanged throughout the time series, which means that commuters are assumed to maintain their travel habits from those observed today.

4. *Modelling the Impact of the Feebate Scheme*

4.1. Introduction

To model the impacts of the feebate scheme, it is necessary to understand how consumers change their vehicle purchasing behaviour when the price of their preferred vehicle and/or the price of other (competing) vehicles change. These are measured by the own price and cross price elasticities of demand for vehicles. Other key components required to model the impact of the feebate scheme are the projected number of vehicle imports (estimated for the baseline scenario) and the projected average price of vehicles with different average CO_2 emissions. Each of these components is inherently uncertain and a comprehensive sensitivity analysis was undertaken to assess the impact of changes in each of these components on the feasibility of this scheme, as further described in section 7.

4.2. Projected Vehicle Prices

The average price of new vehicles falling within different CO_2 emission bands that were imported in 2017 was obtained from an econometric analysis carried out by Covec [8]. These average prices are shown in the Table 3.

Table 3: Average price of a new vehicle by emission band in 2017

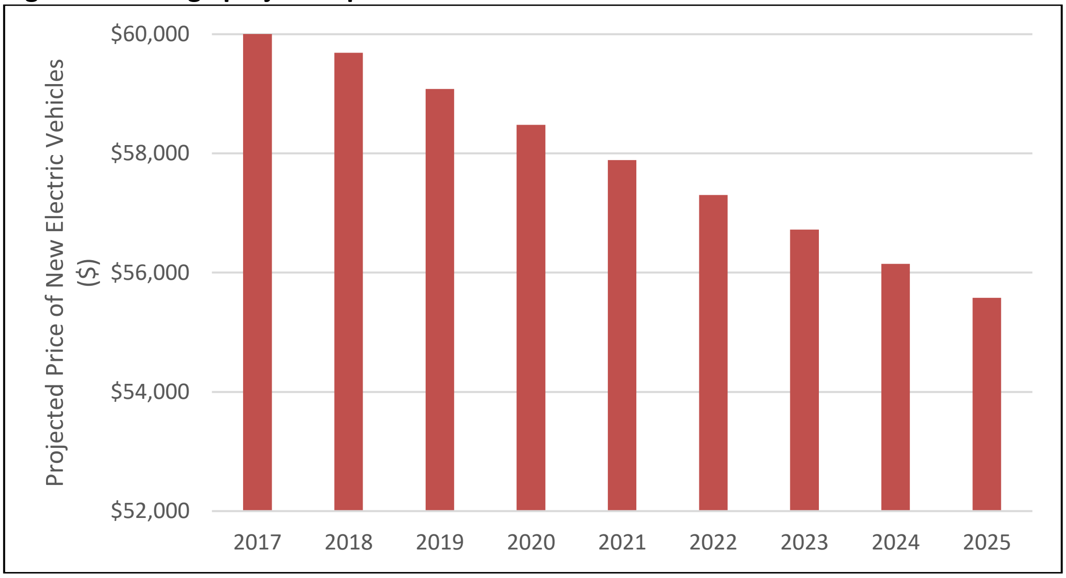
Emission Band (gCO_2/km)	Average price per new vehicle
0 to 4	$60,000
5 to 49	$60,000
50 to 69	$60,000
70 to 89	$28,617
90 to 105	$28,617
106 to 120	$33,122
121 to 130	$35,215
131 to 140	$36,606
141 to 150	$36,965
151 to 160	$37,800
161 to 170	$39,183
171 to 180	$41,298
181 to 190	$43,930
191 to 200	$46,900
200 to 225	$52,542
226 to 250	$58,695
over 251	$65,237

Source: Covec (2017) [8]

Due to a lack of data, the analysis has kept the price of new conventional vehicles unchanged throughout the time series. Notwithstanding, a number of vehicle price scenarios were simulated in the sensitivity analysis, as further described in section 7 below.

In the case of new EVs and hybrid vehicles, the average price was assumed to decline by 1% per annum in real terms (2017 dollars) to reflect the 'Slow EV Uptake' scenario in the VFEM [6]. By comparison, the rate of price decline in the VFEM 'base case' scenario is 2.7% per annum. Further analysis will need to be carried out to understand the sensitivity of the price of electric vehicle on the effectiveness of the feebate scheme. Figure 4 shows the projected average price of a new electric vehicle assumed in the model.

Figure 4: Average projected price of a new electric vehicle



To estimate the price of used ICE vehicles, the analysis assumed that vehicle value depreciates by 20% per annum as vehicles age [8]. It was also assumed that the average age of a used vehicle is 10 years [4]. A fixed cost of import was assumed to be $3,000 per vehicle [8]. The formula used to estimate the price for a used ICE vehicle is represented by the following equation [8].

$$UP_t = (NP - FC) \cdot (1 - PR)^t + FC \qquad (1)$$

Where:

UP_t = used vehicle price imported at age t

NP = new vehicle price

FC = fixed cost of import

PR = percentage reduction in price per annum

The price of a used EVs was based on the weighted average price of vehicles sold in 2015 and 2016 [9]. For subsequent years, a 1% annual price decrease was assumed to project the prices of used EVs in-line with the price decline assumed for new EVs [6].

Incomplete information of vehicle prices by vehicle make and model makes it impossible to estimate the volume-weighted average prices, particularly for used vehicles. For used vehicles, the estimated average price is highly indicative due to the large differences in the vehicle ages and other characteristics between vehicles with price information and that of the imported fleet. As stated above, a rigorous sensitivity analysis was undertaken to model the impact of different average prices, as further shown in section 7.

In addition to the upfront cost of the vehicle, the analysis adds one year of fuel costs to the price of the vehicle because it is assumed that vehicle buyers internalise this cost when choosing their preferred vehicle[5]. The fuel cost is a factor of the average fuel efficiency, the fuel price and the average annual VKT. However, the latter is also dependent on the travel needs of vehicle users and the vehicle's age. The number of years of operating costs that vehicle buyers take into consideration when choosing between different vehicle types have a large impact on the CBA results, as further explained in the sensitivity analysis in section 7.

[5] This implies that consumers do not consider the present value of the full lifetime fuel costs when buying a vehicle.

4.3. Own Price and Cross Price Elasticities of Demand

Price elasticity is a measure of how the demand for a category of vehicle changes in response to both changes in its own price and the prices of other vehicles. The demand for vehicles in any specific category will decrease if its own price rises, whilst conversely, their demand will increase if the price of competing vehicles rises. The elasticities used in this report are sourced from Covec [8], which were based on a study carried out in the UK [10]. In the case of EVs elasticities, the Covec report estimates the average own-price elasticity using a number of international studies [11] [12] [13].

The demand for EVs is projected to increase with improved technology, particularly as driving range rises and battery recharge time falls. Another contributor is the expected decline in both vehicle and battery prices. Hence, a higher rate of substitutability is expected to be observed between ICE vehicles and EVs. This implies that the own-price elasticity of EVs will increase into the future.

In this report, it was assumed that the own-price elasticity of EVs will increase by 7% per year [8]. Table 9 in Annex 2 presents the price and cross elasticities of demand for vehicles falling within different CO_2 emission bands.

5. Cost benefit analysis - Methodology

5.1.1. Quantified Benefits

The CO_2 emission savings and fuel cost savings from the implementation of a feebate scheme have been quantified and valued in monetary terms[6]. Other potential benefits obtained from lower air and noise pollution and from the amelioration of security of supply and trade balance have not been quantified due to data limitations.

5.1.2. CO_2 Emissions Savings

The implementation of a feebate scheme is expected to accelerate the improvement in average CO_2 emissions of the vehicle imports. The CO_2 savings are estimated by multiplying the improvement in the average CO_2 emissions of the imported vehicles by the number of vehicles imported in each year and multiplied again by the average lifetime of the vehicle (which varies according to whether it is a new or used vehicle and depending on the age of the vehicle).

The total annual CO_2 savings are summed up to obtain the total gross emissions savings (in tonnes) over the evaluation period (2020-2041). This period covers the policy implementation timeframes (2020-2025) and the benefits and costs that continue to be incurred post-2025.

As stated above, this analysis assumes that this policy intervention will incentivise the purchase of EVs and thus, the emissions generated from the electricity needed to power these additional[7] EVs must be accounted for and deducted from the gross emissions savings accordingly. These additional emissions are estimated in a similar fashion to the CO_2 savings, namely by multiplying the number of additional EVs by their average lifetime and average annual vehicle kilometres driven by EV users.

It is assumed that this substitution in favour of EVs will be subject to the rebound effect. The rebound effect is the reduction in the gains from adopting new technologies that increase the efficiency of the resource use due to behavioural changes of the user. In the context of this study, this means that users of EVs will drive them for a longer distance since it is perceived that the fuel cost relative to an ICE vehicle is very low. In this analysis, the rebound effect has been accounted for by deducting the fuel savings by 10% throughout the time series. Given the lack of data on this effect, the appropriate uncertainty levels were simulated in the sensitivity analysis to gauge the impact on the net benefits of this intervention, as further detailed in section 7.

The additional emissions from accelerating the substitution in favour of EVs are summed up and deducted from the gross emissions savings in order to obtain the net emissions savings from this policy intervention. The net CO_2 savings are subsequently converted in monetary terms by multiplying the tonnes of emissions savings by the projected price of carbon as published in New Zealand's Seventh National Communication to the UNFCCC[8] [14] and the results are then converted to present values using a real discount rate of 6% p.a. Different carbon values were tested in the sensitivity analysis including the average social cost of carbon of \$40/tCO_2 shown in the EEM to understand the impact of this parameter has on the overall results.

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[6] All cost/price values are in 2017 New Zealand dollars, unless otherwise specified.

[7] Additional EVs relative to the base case scenario.

[8] A review of the current carbon price or recommended carbon cost reveals a number of different figures, including €13/tonne ($22/tonne @0.58 exchange rate) (EU ETS) [21], $21.50/tonne (NZ ETS) [19], $40/tonne (EEM) [16], and US$105 (150/tonne @ 0.71 exchange rate) (EPA) [22].

5.1.3. Fuel Cost Savings

Fuel cost savings are enjoyed by consumers who decide to purchase vehicles with a lower fuel consumption. The extent of these savings will depend on a range of factors, including retail fuel prices, the user's travel needs and the type of vehicle purchased, which in turn depends on consumer preferences and choice availability.

For modelling purposes, the fuel cost savings were assumed to be a function of the CO_2 improvements in the vehicle imports fleet divided by the weighted average GHG conversion factor [6]. When estimating the fuel savings (in dollars), the savings in the first year have been excluded since the analysis assumed consumers have already taken these savings into consideration when weighing different purchase options and in their choice of preferred vehicle.

The estimated fuel cost savings are then multiplied by the projected fuel prices (exclusive of GST and ETS) [15]. Given the uncertain nature of future fuel prices, the sensitivity analysis detailed in section 7 tested a 'high price' and 'low price' scenarios as published by the Ministry of Business, Innovation and Employment [15]. The projected fuel prices are shown in Figure 5 and Figure 6 below.

Figure 5: Petrol Price Projections

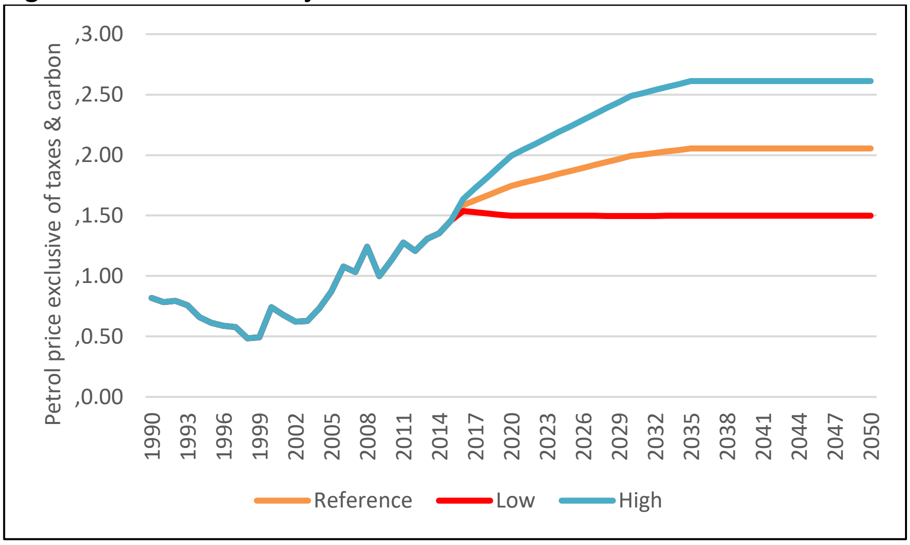
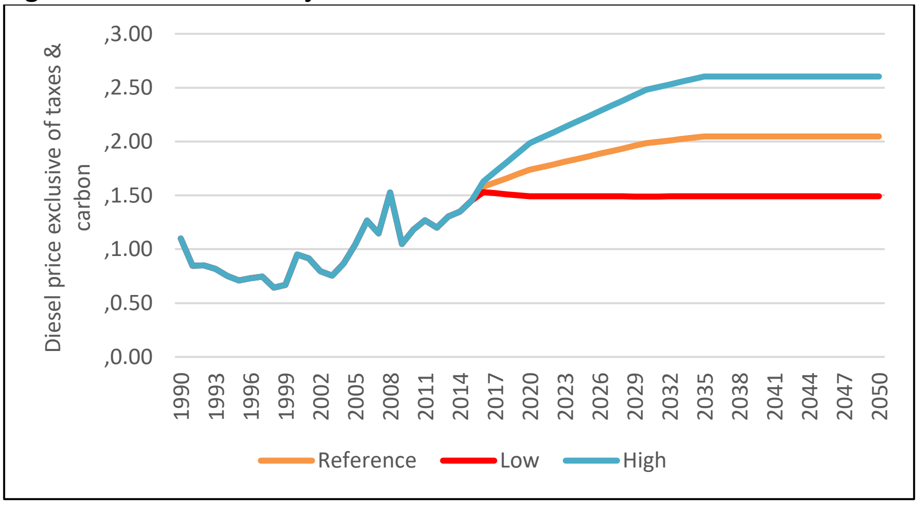


Figure 6: Diesel Price Projections



5.1.4. Other Benefits

As stated above, the benefits from accelerating the average CO_2 emissions of the vehicle import fleet may extend to other areas such as lower air pollution due to the more widespread use of fuel efficient ICE vehicles and possibly lower noise pollution from the increased uptake of EVs. However, this analysis has not estimated these benefits because they would depend on the concentrations of air or noise pollution within populated areas rather than solely from the vehicle numbers themselves.

Another potential benefit from this policy intervention is improvements in the security of supply from importing lower volumes of fuel. A smaller import fuel bill would also favourably impact the trade balance given that New Zealand relies heavily on fossil fuel imports. Notwithstanding, this benefit is expected to be relatively small given that fuel imports only accounted for around 5% of total import values in 2017.

Due to the lack of data available on the above benefits, their quantified and monetary impact has been excluded from this report. Therefore, the benefits to society are likely to be higher than the ones being quantified in this report.

5.2. Quantified Costs

5.2.1. Welfare Impact

The feebate scheme is expected to induce behavioural changes in consumers' purchasing decisions through changes in the price of their preferred vehicle. Some consumers will opt to purchase a vehicle that was different from their preferred one (in terms of vehicle type, engine size or some other characteristic) or a vehicle that is more expensive (due to the additional cost of installing technologies to improve its fuel efficiency or to abate CO_2 emissions). Either way, this will lead to a loss in consumer welfare, as estimated by the 'deadweight loss' shown in Table 4.

Table 4: Estimated loss in consumer welfare (deadweight loss) from the Feebate Scheme by Vehicle Type

	New Vehicles	Used Vehicles	Total
2020	$15.09	$5.77	$20.85
2021	$21.46	$6.63	$28.09
2022	$31.22	$7.66	$38.89
2023	$44.68	$8.22	$52.90
2024	$54.09	$8.82	$62.91
2025	$66.59	$10.40	$76.99
Total	**$233.13**	**$47.51**	**$280.64**

^ Figures are in millions and discounted at 6% p.a.

The extent of these welfare losses will depend on a number of factors, including the consumer response to vehicle price changes and how importers will alter their fleet profile following changes in consumers' purchasing preferences. In this analysis, the consumer welfare impact was estimated by multiplying the projected changes in vehicle demand under different CO_2 emissions bands by their respective feebate rate and dividing the result by two given that the loss pertains to consumers.

It is recognised that estimating the impact on consumers' welfare is difficult to accurately determine given the number of uncertainties in key variables, particularly those related to consumers' preferences, importers' selling strategies and price elasticities of different vehicle types, amongst others.

5.2.2. Implementation Costs

The government is expected to incur an initial capital cost to implement and regulate this scheme. This capital cost is expected to be around $7.5 million and will be required to develop an automated submission and payment processes using online and to carry out changes in the MVR software. This cost is assumed to be wholly incurred in the year prior to the start of this intervention (2019).

In addition, the government will incur operational costs to install the necessary processes required to handle the fee collection and administration of this scheme, as well as for awareness-raising and communication campaigns. Regular auditing would also be required to maintain cash inflows and outflows within the pre-determined budget. These operating costs are expected to be $2.75 million per year, starting from 2020 and running till 2034 for used vehicles and 2041 for new vehicles to reflect the economic lifetime of each vehicle type purchased in the last year of this intervention (2025). The total discounted implementation costs are estimated to range between $31 million - $44 million (midpoint $37 million) for the duration of this intervention (2020-2041).

5.2.3. Other Costs

Impacts from the implementation of a feebate scheme that have not been considered in this CBA due to the lack of data include:

- It may incentivise vehicle users to extend the lifetime of existing vehicles that are high emitters. Since a fee will be levied on new high emission vehicles, some users may opt to postpone their purchase of a new vehicle and to hold onto their current vehicle for a longer time period.
- It could lead to a change in vehicle scrappage rate resulting in changes in the domestic second hand market. The provision of a rebate on the purchase of new vehicles effectively makes them cheaper and thus more affordable. This may incentivise some users to scrap their existing vehicle and buy a new one at an earlier date than would otherwise be the case. On the other hand, adding a fee on vehicles that use more fuel makes bigger vehicle more expensive and therefore encourage perspective buyers to hold on their vehicles for longer. The net change to the vehicle scrappage rate will depend on the relative forces of the two impacts. To discourage the latter impact, it is necessary to complement this policy intervention with a vehicle scrappage scheme.
- It could change travellers' mode choice decisions between road transport and public transport or active modes. Notwithstanding, it is expected that this effect would be minor.

6. Cost benefit analysis – Results

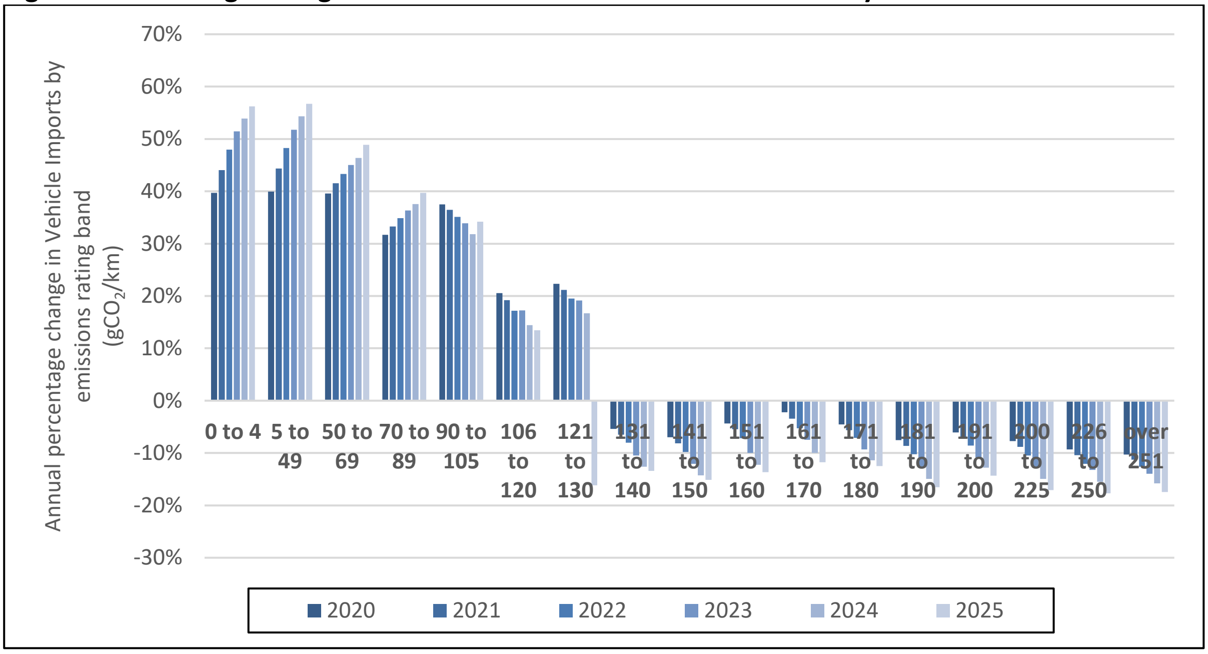
The analysis assumed the intervention starts in 2020 (year 1). Therefore, the evaluation period covers 2019 (year 0) to 2041 to include the initial capital costs and the impact from the purchase of a new vehicle in the last year of this intervention (2025) over its expected lifetime (17 years). The analysis is mostly based on data collected for 2016 and 2017. All prices are expressed in 2017 dollars. All present values are calculated using a 6% real discount rate per annum [16].

6.1. New Fleet Composition

The impact of the feebate scheme on consumer demand is based on the own price and cross price elasticities to estimate the change in the composition of the vehicle imports in favour of low-emissions vehicles. Another impact is the expected substitution from new to used vehicles as a result of the feebate scheme. This was modelled exogenously by assuming a shift of 5% in the number of ICE vehicle imports having an average emission rating of 131 gCO_2/km or greater from new to used vehicles.

The shift in consumer demand in favour of vehicles having lower average emissions accelerates as the feebates are set at a higher rate and are gradually increased overtime. Figure 7 shows the percentage change in vehicle sales as compared with the imports projected in the baseline scenario.

Figure 7: Percentage change in the number of new and used vehicles by emission band



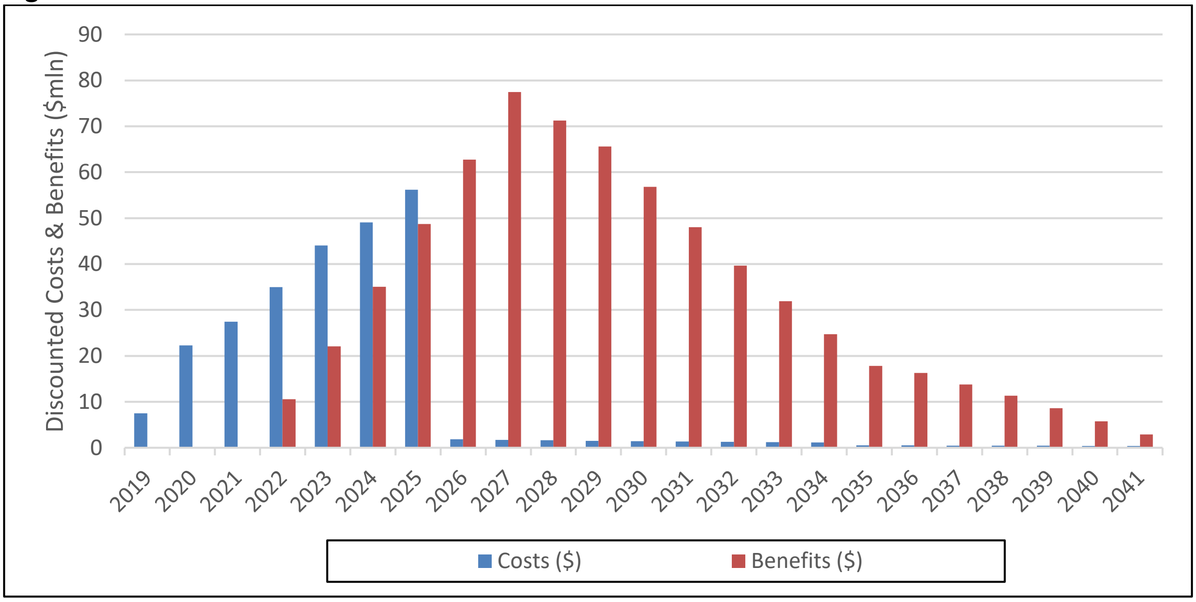
The above Figure shows a gradual reduction in the number of vehicle imports having an average CO_2 level that is greater than 120 gCO_2/km in favour of vehicles that have a lower average CO_2 level. The rate of growth in vehicles having an average CO_2 level of 105 gCO_2/km or lower is accelerated in the later years of this scheme, apart from vehicles having an average emission of between 90 gCO_2/km and 105 gCO_2/km, which receive a lower rebate than vehicles having better average emission levels. By 2025, it is assumed that very low-emission vehicles such as EVs and hybrids (generally having average emissions of less than 50 gCO_2/km), would have reached near-to-full cost parity with the conventional vehicles.

6.2. Net Benefits

The feebate scheme is expected to achieve an emission reduction ranging between 1 million - 2.3 million tonnes of CO_2 (midpoint 1.5 million) over evaluation period (2020-2041). Approximately 51% of this reduction is achieved from the change in the vehicle import composition in favour of new and more fuel efficient vehicles, particularly the substantial increase in new EVs.

The total net benefit from the implementation of the feebate scheme is estimated to range from $111 million - $821 million (midpoint $413 million) over the evaluation period. Almost all the benefits (93.3%) are from fuel cost savings by vehicle users, with the remaining 6.6% gained by the wider society from lower GHG emissions if a mid-range carbon price of $27/tonne is assumed. The net benefits vary on an annual basis to reflect the changing costs and benefits as the feebate rates are revised. The annual costs and benefits are shown in Figure 8 and summarised in Annex 3.

Figure 8: Annual Costs and Benefits



6.3. Economic viability

The main indicators of economic viability are the Benefit/Cost Ratio (BCR) and the Net Present Value (NPV). The Marginal Abatement Cost (MAC) is also shown for comparative purposes with other potential emissions mitigation measures. The MAC represents the net benefit (or cost) in societal welfare from reducing an additional tonne of CO_2 emissions. When there is a net cost (benefit) to reduce an additional tonne of CO_2 emission, the MAC has a positive (negative) value. Thus, the MAC is one way to rank different options based on the relative marginal costs and benefits. By definition, MAC does not include fixed costs and therefore is slightly different from what may be implied based on the BCR. The results of the economic indicators are shown in Table 5.

Table 5: Results of the Main Indicators for Economic Viability

	Mid-Range	90% Confidence Interval	
		Min	Max
Benefit-Cost Ratio	2.6	1.4	4.2
Net Present Value ($ million)	413	111	821
Marginal Abatement Cost ($/t$CO_2$)	-266	-423	-90
Reduction in GHG emission (million tons CO_2)	1.6	1.0	2.3

The above table indicates that for every dollar that is spent on this intervention, society in general would obtain between $1.4 – $4.2 (midpoint $2.6) in benefits, as indicated by the BCR. In monetary terms, this net benefit would amount to between $111 million - $ 821 million (midpoint $431 million) over the whole period, as shown by the NPV. The MAC is negative and substantial, meaning that the marginal cost of abating the additional tonne of CO_2 would result in a net social benefit of $266 per tonne with ranges between $90 - $423 per tonne. It is estimated that motorists would enjoy the largest share of these benefits by saving about $627 million (ranging between $328 million - $1.05 billion) on fuel over the life of the vehicles affected by the scheme, or about $5,200 per vehicle.

Apart from the positive net benefits to society, it is expected that the feebate scheme will also have distributional impacts between those buyers who pay a fee on the purchase a high-emissions vehicle to those buyers who are given a rebate on the purchase of a low-emitting vehicle. Thus, it is important to identify the income cohorts that would be adversely affected and what would the impact be on their welfare. The groups that could potentially be affected include families that have two or more children and require bigger and less fuel-efficient vehicles; low income families that opt to purchase a (cheaper but less fuel-efficient) used vehicle and tradesmen who need light trucks to ply their trade. A separate Social Impact Assessment will be carried out to provide a better picture on the distributional impacts from this intervention.

7. Sensitivity Analysis

An extensive sensitivity analysis was carried out in order to account for the inherent uncertainties in key parameters and to identify those ones that have a significant impact on the economic viability of this scheme. A sensitivity analysis also establishes the robustness of the results subject to alternative parameter values and scenarios. Table 6 lists the key parameters that have been simulated.

Table 6: Key Parameters simulated in the sensitivity analysis

Discount Rate (Policy)
Discount Rate (Financial)
Fuel Price
Carbon Price
Electricity Price
Average Purchase Price of New Vehicles in base year
Average Purchase Price of Used Vehicles in base year
Annual Change in the Average Purchase Price of New Vehicles
Annual Change in the Average Purchase Price of Used Vehicles
Depreciation Rate of Used Vehicles
Import Cost of Used Vehicles
Own Price Elasticity of New Vehicles
Own Price Elasticity of Used Vehicles
Cross Price Elasticity of New Vehicles
Cross Price Elasticity of Used Vehicles
Annual % change in own-price elasticity of EVs
Growth Rate in New Vehicle Imports
Growth Rate in Used Vehicle Imports
Average Lifetime of a New Vehicle
Average Lifetime of a Used Vehicle
Average VKT driven by a Conventional Vehicle
Average VKT driven by an Electric/Hybrid Vehicle
Annual Decrease in VKT driven
Rebound Effect
Substitution Effect
Implementation Cost (CAPEX)
Implementation Cost (OPEX)

The parameter that represents the extent to which vehicle buyers internalise the operating costs of their preferred vehicle in their purchase decision ("Internalisation of Fuel Cost") was analysed separately given that the uncertainty is quite high. Furthermore, the impact on the feasibility of this intervention from varying this parameter is also relatively high. Economic theory states that a 'rational' individual would consider the full operating cost of all vehicle types available on the market and will subsequently purchase the one that maximises his/her utility over the whole lifetime of the vehicle. This implies that the individual would purchase the most fuel efficient vehicle available on the market since the fuel savings obtained therefrom would outweigh the additional 'technology' cost of these vehicle types. Hence, it follows that direct government intervention to change consumer behaviour would not be required since a 'rational' individual would automatically choose the best option.

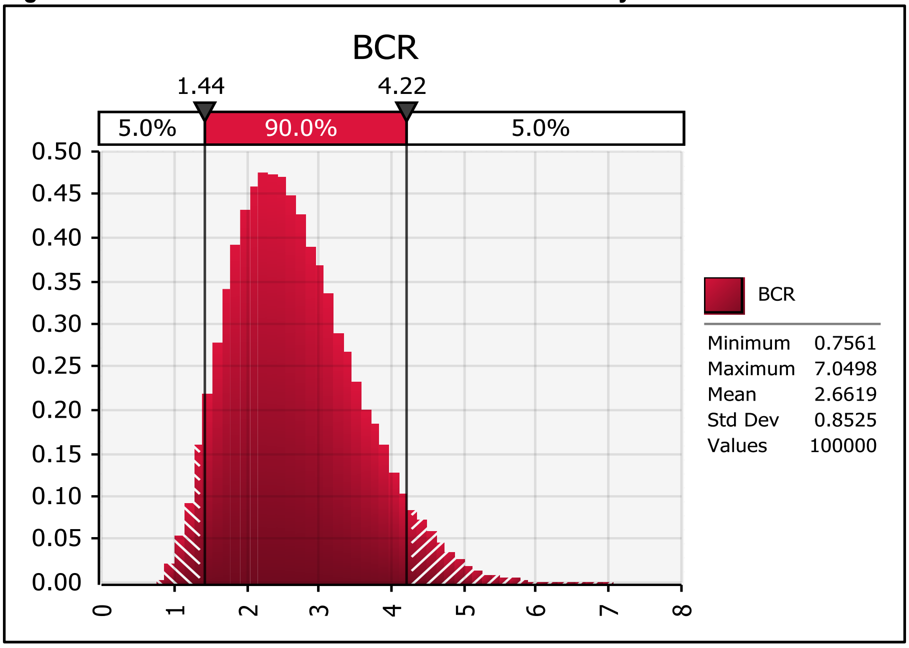
However, various studies show that individuals do not internalise the full operating cost of their preferred type and will only consider the total cost of operating the vehicle over one or two years.

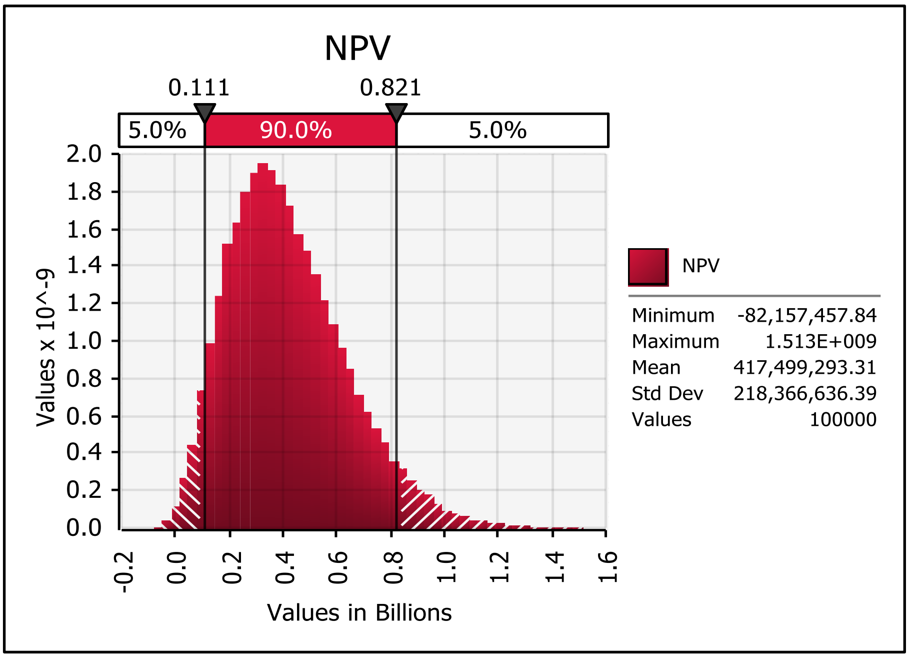
Therefore, the need for government intervention to incentivise a change in behaviour in favour of fuel efficiency or low emissions vehicles.

A Monte Carlo simulation was carried out to test the impact on the economic viability indicators (shown in Table 5) when changing the key assumptions (listed in Table 6) and a separate simulation was carried out to test the "Internalisation Fuel Cost" parameter. The minimum and maximum variation simulated for each key parameter, including at the 5% and 95% confidence level, are listed in Annexes 4 and 5.

The results of the simulation indicate that the feebate scheme is economically viable, at a 90% confidence interval, as attested by a BCR that varies between 1.44 and 4.22 and an NPV that varies between $111 million and $821 million when applying the uncertainty margins of each key parameter simultaneously. The results are shown in Figure 9 below.

Figure 9: Results of the Monte Carlo Simulation on Key Parameters

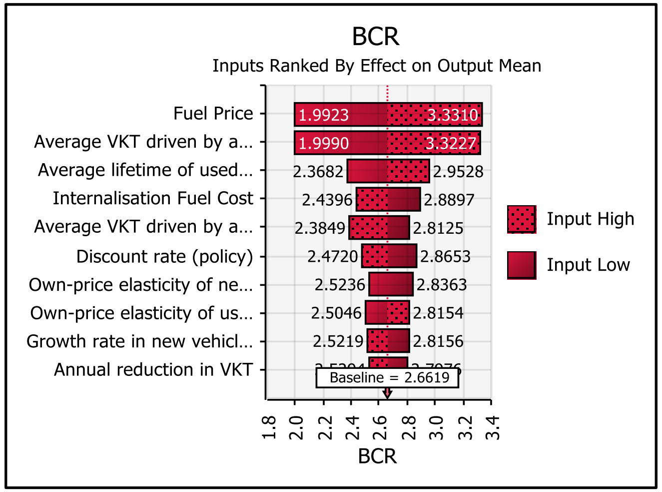




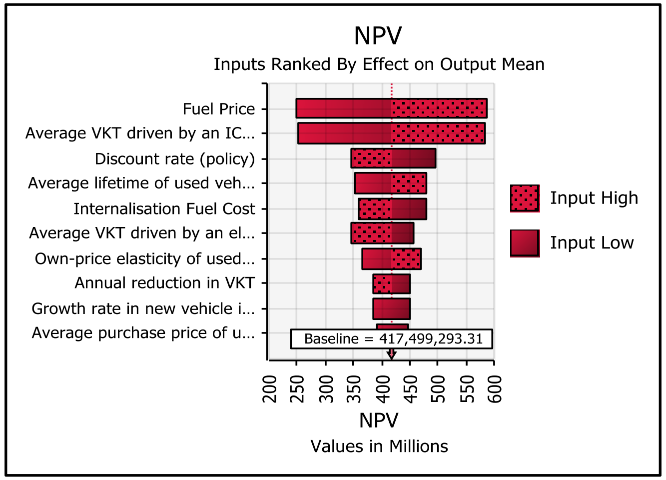
The key parameters that have the greatest impact on the BCR and NPV are shown in Table 7 below.

Table 7: Top 10 Key Parameters

Change in Output Statistic for BCR			
Rank	**Name**	**Lower**	**Upper**
1	Fuel Price	1.99	3.33
2	Average VKT driven by an ICE vehicle	2.00	3.32
3	Average lifetime of used vehicles	2.37	2.95
4	Internalisation Fuel Cost	2.44	2.89
5	Average VKT driven by an electric/hybrid vehicle	2.38	2.81
6	Discount rate (policy)	2.47	2.87
7	Own-price elasticity of new vehicles	2.52	2.84
8	Own-price elasticity of used vehicles	2.50	2.82
9	Growth rate in new vehicle imports	2.52	2.82
10	Annual reduction in VKT	2.53	2.80



Change in Output Statistic for NPV			
Rank	**Name**	**Lower**	**Upper**
1	Fuel Price	248	585
2	Average VKT driven by an ICE vehicle	251	583
3	Discount rate (policy)	347	495
4	Average lifetime of used vehicles	351	481
5	Internalisation Fuel Cost	359	479
6	Average VKT driven by an electric/hybrid vehicle	347	456
7	Own-price elasticity of used vehicles	367	469
8	Annual reduction in VKT	384	451
9	Growth rate in new vehicle imports	386	449
10	Average purchase price of used vehicles in base year	393	447



Annex 1 - Feebate Schedules

Table 8: Feebate Schedules applicable to New and Used Imported Vehicles

	New Vehicle Imports																
	Emissions Band (gCO_2/km)																
	Rebate						Fee										
	0 to 4	5 to 49	50 to 69	70 to 89	90 to 105	106 to 120	121 to 130	131 to 140	141 to 150	151 to 160	161 to 170	171 to 180	181 to 190	191 to 200	200 to 225	226 to 250	over 251
2020	-$5,000	-$5,000	-$5,000	-$2,900	-$2,900	$0	$0	$2,200	$2,200	$2,300	$2,400	$2,500	$2,700	$2,900	$3,200	$3,600	$4,000
2021	-$5,000	-$5,000	-$5,000	-$2,900	-$2,900	$0	$0	$2,200	$2,200	$2,300	$2,400	$2,500	$2,700	$2,900	$3,200	$3,600	$4,000
2022	-$5,000	-$5,000	-$5,000	-$2,900	-$2,900	$0	$0	$2,200	$2,200	$2,300	$2,400	$2,500	$2,700	$2,900	$3,200	$3,600	$4,000
2023	-$5,000	-$5,000	-$5,000	-$2,800	-$2,800	$0	$0	$3,100	$3,100	$3,200	$3,300	$3,500	$3,700	$4,000	$4,500	$5,000	$5,000
2024	-$5,000	-$5,000	-$5,000	-$2,800	-$2,800	$0	$0	$3,100	$3,100	$3,200	$3,300	$3,500	$3,700	$4,000	$4,500	$5,000	$5,000
2025	-$5,000	-$5,000	-$5,000	-$2,800	-$2,800	$0	$2,100	$3,100	$3,100	$3,200	$3,300	$3,500	$3,700	$4,000	$4,500	$5,000	$5,000

	Used Vehicle Imports																
	Emissions Band (gCO_2/km)																
	Rebate						Fee										
	0 to 4	5 to 49	50 to 69	70 to 89	90 to 105	106 to 120	121 to 130	131 to 140	141 to 150	151 to 160	161 to 170	171 to 180	181 to 190	191 to 200	200 to 225	226 to 250	over 251
2020	-$1,000	-$1,000	-$900	-$600	-$600	$0	$0	$700	$700	$700	$700	$700	$800	$800	$900	$900	$1,000
2021	-$1,000	-$1,000	-$900	-$600	-$600	$0	$0	$700	$700	$700	$700	$700	$800	$800	$900	$900	$1,000
2022	-$1,000	-$1,000	-$900	-$600	-$600	$0	$0	$700	$700	$700	$700	$700	$800	$800	$900	$900	$1,000
2023	-$1,000	-$1,000	-$900	-$600	-$600	$0	$0	$700	$700	$700	$700	$700	$800	$800	$900	$900	$1,000
2024	-$1,000	-$1,000	-$900	-$600	-$600	$0	$0	$700	$700	$700	$700	$700	$800	$800	$900	$900	$1,000
2025	-$1,000	-$1,000	-$900	-$600	-$600	$0	$700	$700	$700	$700	$700	$700	$800	$800	$900	$900	$1,000

Annex 2 - Elasticities

Table 9: Cross and own price elasticities

		Emissions Band (gCO_2/km)																
		0 to 4	**5 to 49**	**50 to 69**	**70 to 89**	**90 to 105**	**106 to 120**	**121 to 130**	**131 to 140**	**141 to 150**	**151 to 160**	**161 to 170**	**171 to 180**	**181 to 190**	**191 to 200**	**201 to 225**	**226 to 250**	**<251**
CO_2 Emissions Band	**0 to 4**	**-4.30%**	0.19%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%
	5 to 49	0.02%	**-4.30%**	0.19%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%
	50 to 69	0.02%	0.02%	**-4.30%**	0.19%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%
	70 to 89	0.02%	0.02%	0.02%	**-4.30%**	0.19%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%
	90 to 105	0.02%	0.02%	0.02%	0.19%	**-3.58%**	0.56%	0.52%	0.35%	1.82%	0.14%	0.02%	0.10%	0.14%	0.00%	0.00%	0.00%	0.00%
	106 to 120	0.13%	0.13%	0.13%	0.13%	0.13%	**-3.80%**	0.28%	0.48%	1.22%	0.62%	0.19%	0.35%	0.20%	0.05%	0.03%	0.01%	0.00%
	121 to 130	0.09%	0.09%	0.09%	0.09%	0.09%	0.22%	**-3.95%**	0.45%	0.99%	0.65%	0.33%	0.46%	0.24%	0.11%	0.07%	0.03%	0.00%
	131 to 140	0.02%	0.02%	0.02%	0.02%	0.02%	0.15%	0.17%	**-3.44%**	0.89%	0.79%	0.32%	0.49%	0.24%	0.10%	0.07%	0.02%	0.00%
	141 to 150	0.06%	0.06%	0.06%	0.06%	0.06%	0.20%	0.20%	0.47%	**-2.87%**	0.72%	0.23%	0.43%	0.22%	0.09%	0.07%	0.02%	0.00%
	151 to 160	0.00%	0.00%	0.00%	0.00%	0.00%	0.10%	0.13%	0.40%	0.67%	**-3.22%**	0.37%	0.51%	0.28%	0.15%	0.18%	0.07%	0.01%
	161 to 170	0.00%	0.00%	0.00%	0.00%	0.00%	0.06%	0.13%	0.34%	0.44%	0.73%	**-3.47%**	0.67%	0.37%	0.23%	0.20%	0.09%	0.01%
	171 to 180	0.00%	0.00%	0.00%	0.00%	0.00%	0.07%	0.11%	0.32%	0.49%	0.65%	0.47%	**-3.43%**	0.30%	0.22%	0.20%	0.08%	0.01%
	181 to 190	0.01%	0.01%	0.01%	0.01%	0.01%	0.05%	0.09%	0.23%	0.38%	0.54%	0.37%	0.46%	**-3.42%**	0.19%	0.24%	0.10%	0.03%
	191 to 200	0.00%	0.00%	0.00%	0.00%	0.00%	0.02%	0.05%	0.13%	0.20%	0.37%	0.29%	0.43%	0.22%	**-2.86%**	0.28%	0.12%	0.06%
	201 to 225	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	0.02%	0.05%	0.09%	0.26%	0.15%	0.23%	0.15%	0.17%	**-2.33%**	0.16%	0.09%
	226 to 250	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.02%	0.04%	0.06%	0.19%	0.13%	0.17%	0.12%	0.14%	0.31%	**-2.55%**	0.10%
	< 251	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	0.02%	0.01%	0.03%	0.04%	0.07%	0.18%	0.11%	**-1.83%**

Note: Percentage change in sales for row category from 1% change in price in column category

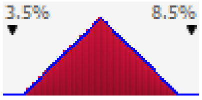
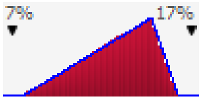
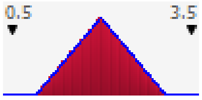
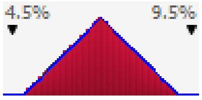
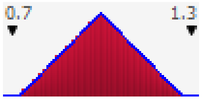
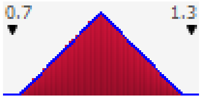
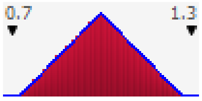
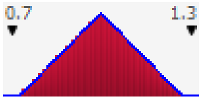
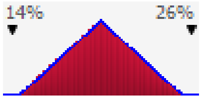
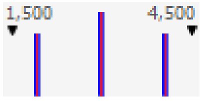
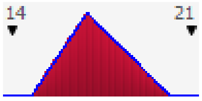
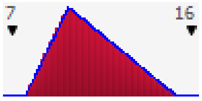
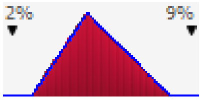
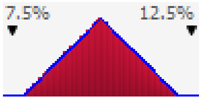
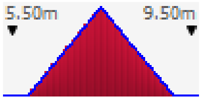
Annex 3 - Annual Costs and Benefits

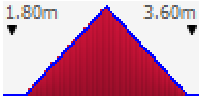
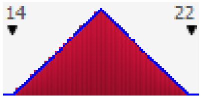
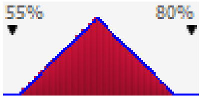
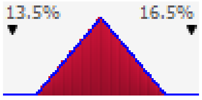
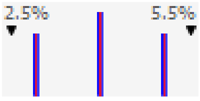
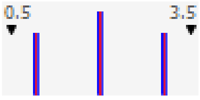
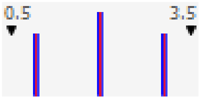
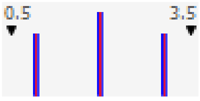
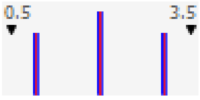
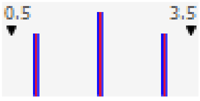
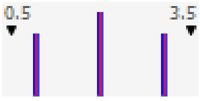
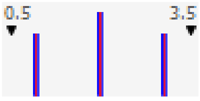
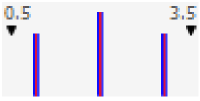
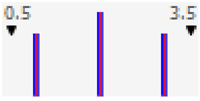
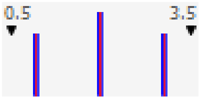
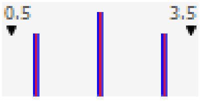
Table 10: Annual Costs and Benefits

Financial Year	Implementation Year	Undiscounted Costs & Benefits							Discounting Factor @ 6%	Discounted Costs & Benefits						
		Costs ($ mln)			Benefits ($ mln)			Net Benefit ($mln)		Costs ($ mln)			Benefits ($ mln)			Net Benefit ($ mln)
		Welfare Loss	Implementation Cost	Total Costs	Fuel Savings	GHG emissions	Total Benefits			Welfare Loss	Implementation Cost	Total Costs	Fuel Savings	GHG emissions	Total Benefits	
2019	0	-	7.5	7.5	-	-	-	-7.5	1.0	-	7.5	7.5	-	-	-	-7.5
2020	1	20.9	2.8	23.6	-	-	-	-23.6	0.9	19.7	2.6	22.3	-	-	-	-22.3
2021	2	28.1	2.8	30.8	-	-	-	-30.8	0.9	25.0	2.5	27.5	-	-	-	-27.5
2022	3	38.9	2.8	41.6	12.2	0.5	12.6	-29.0	0.8	32.7	2.3	35.0	10.2	0.4	10.6	-24.4
2023	4	52.9	2.8	55.7	26.7	1.1	27.9	-27.8	0.8	41.9	2.2	44.1	21.2	0.9	22.1	-22.0
2024	5	62.9	2.8	65.7	44.8	2.1	46.9	-18.8	0.8	47.0	2.1	49.1	33.5	1.6	35.1	-14.0
2025	6	77.0	2.8	79.7	65.8	3.3	69.2	-10.6	0.7	54.3	1.9	56.2	46.4	2.4	48.8	-7.5
2026	7	-	2.8	2.8	89.4	4.9	94.3	91.5	0.7	-	1.8	1.8	59.4	3.3	62.7	60.9
2027	8	-	2.8	2.8	116.4	7.0	123.4	120.7	0.6	-	1.7	1.7	73.1	4.4	77.4	75.7
2028	9	-	2.8	2.8	113.2	7.2	120.4	117.6	0.6	-	1.6	1.6	67.0	4.3	71.3	69.6
2029	10	-	2.8	2.8	110.1	7.5	117.5	114.8	0.6	-	1.5	1.5	61.5	4.2	65.6	64.1
2030	11	-	2.8	2.8	100.6	7.2	107.8	105.1	0.5	-	1.5	1.5	53.0	3.8	56.8	55.4
2031	12	-	2.8	2.8	89.7	7.0	96.7	93.9	0.5	-	1.4	1.4	44.6	3.5	48.0	46.7
2032	13	-	2.8	2.8	78.1	6.5	84.6	81.9	0.5	-	1.3	1.3	36.6	3.1	39.7	38.4
2033	14	-	2.8	2.8	66.2	5.9	72.1	69.4	0.4	-	1.2	1.2	29.3	2.6	31.9	30.7
2034	15	-	2.8	2.8	54.1	5.2	59.3	56.6	0.4	-	1.2	1.2	22.6	2.2	24.8	23.6
2035	16	-	1.4	1.4	41.1	4.3	45.3	43.9	0.4	-	0.5	0.5	16.2	1.7	17.8	17.3
2036	17	-	1.4	1.4	39.4	4.3	43.8	42.4	0.4	-	0.5	0.5	14.7	1.6	16.3	15.7
2037	18	-	1.4	1.4	35.3	4.1	39.4	38.0	0.4	-	0.5	0.5	12.4	1.4	13.8	13.3
2038	19	-	1.4	1.4	30.5	3.7	34.2	32.8	0.3	-	0.5	0.5	10.1	1.2	11.3	10.9
2039	20	-	1.4	1.4	24.4	3.2	27.6	26.2	0.3	-	0.4	0.4	7.6	1.0	8.6	8.2
2040	21	-	1.4	1.4	17.2	2.4	19.5	18.1	0.3	-	0.4	0.4	5.1	0.7	5.7	5.3
2041	22	-	1.4	1.4	9.2	1.3	10.5	9.1	0.3	-	0.4	0.4	2.5	0.4	2.9	2.5
Total		**280.6**	**58.4**	**339.0**	**1164.3**	**88.6**	**1253.0**	**914.0**		**220.5**	**37.4**	**257.9**	**626.7**	**44.4**	**671.1**	**413.2**

Annex 4 - Monte Carlo Simulation: Key Input Parameters

Table 11: Key Input Parameters

Name	Graph	Min	Mean	Max	5%	95%
Discount rate (policy)		4%	6%	8%	5%	7%
Discount rate (financial)		8.0%	12.9%	16.0%	9.6%	15.3%
Internalisation Fuel Cost		1.00155	2	2.99762	1.316209	2.683764
Annual % change in own-price elasticity of Evs		5%	7%	9%	6%	8%
Own-price elasticity of new vehicles		0.7503557	1	1.249219	0.8290557	1.170936
Cross-price elasticity of new vehicles		0.7507959	1	1.24974	0.8290527	1.17094
Own-price elasticity of used vehicles		0.7509511	1	1.248903	0.8290553	1.170941
Cross-price elasticity of used vehicles		0.7501878	1	1.249328	0.8290513	1.170939
Depreciation rate of used vehicles		15%	20%	25%	17%	23%
Import cost of used vehicles		$2,000	$3,000	$4,000	$2,000	$4,000
Average lifetime of new vehicles		15.01	17.33	19.99	15.71	19.13
Average lifetime of used vehicles		8.01	11.00	14.99	8.84	13.68
Substitution effect		3%	5%	8%	4%	7%
Rebound Effect		8%	10%	12%	9%	11%
Implementation cost (CAPEX)		$6,002,058	$7,500,000	$8,995,521	$6,474,316	$8,525,642

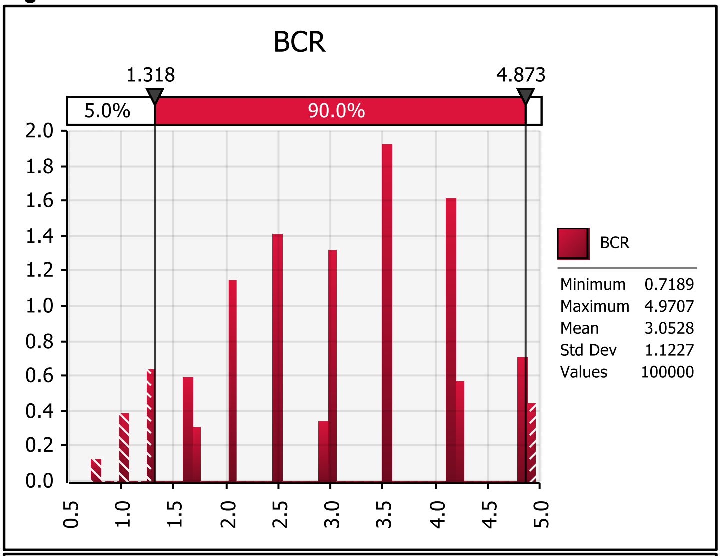
Name	Graph	Min	Mean	Max	5%	95%
Implementation cost (OPEX)		$2,002,009	$2,750,000	$3,497,369	$2,237,157	$3,262,823
ETS		14.40391	18	21.58871	15.5384	20.46157
ETS %		57%	67%	77%	60%	74%
GST		14%	15%	16%	14%	16%
Annual reduction in VKT		3%	4%	5%	3%	5%
Fuel Price		1	2	3	1	3
Carbon Price		1	2	3	1	3
Electricity Price		1	2	3	1	3
Annual change in the average purchase price of used vehicles		1	2	3	1	3
Annual change in the average purchase price of new vehicles		1	2	3	1	3
Average purchase price of used vehicles in base year		1	2	3	1	3
Average purchase price of new vehicles in base year		1	2	3	1	3
Average VKT driven by an ICE vehicle		1	2	3	1	3
Growth rate in used vehicle imports		1	2	3	1	3
Growth rate in new vehicle imports		1	2	3	1	3
Average VKT driven by an electric/hybrid vehicle		1	2	3	1	3

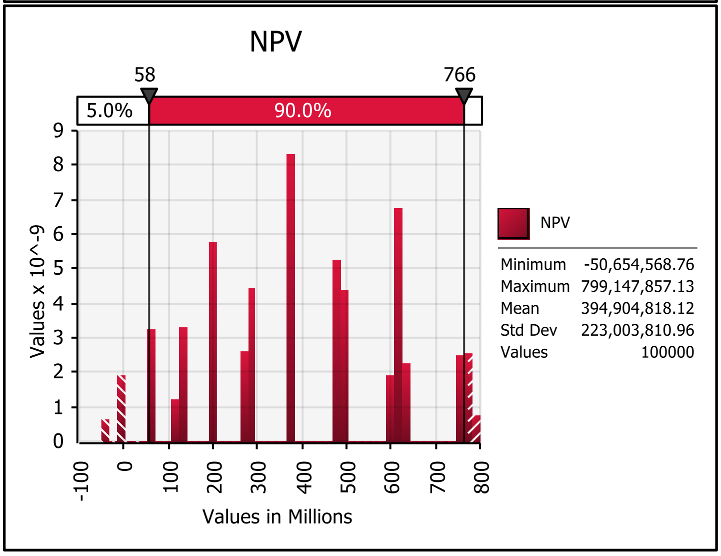
Annex 5 - Monte Carlo Simulation of the "Internalisation of Fuel Cost" Parameter

Table 12: Results of the Monte Carlo Simulation on "Internalisation of Fuel Cost" Parameter

	Lower	Upper
Output Statistic for BCR	0.72	4.97
Output Statistic for NPV	-$50 million	$799 million

Figure 10: Confidence Levels of the "Internalisation Fuel Cost" Parameter





Annex 6 – Comparison of Economic Indicators from applying different Social Cost of Carbon

The monetary benefits from CO_2 savings depend on the social cost of carbon that is used to convert the estimated impacts from tonnes to dollar values. In this analysis, the carbon price has been used as a proxy and was taken from New Zealand's Seventh National Communication to the UNFCCC [17] as shown in Table 13. A linear extrapolation was used to obtain figures for the interim years while for post-2030, the price was maintained at $25/tCO_2e.

Table 13: Carbon Prices

	$ per tCO_2e
2010	19.50
2015	15.21
2016	17.15
2020	19.57
2025	22.58
2030	25.00

Various 'carbon prices' or social cost of carbon exist both in New Zealand publications and from literature around the world. In NZTA's EEM, a social cost of $40/tonne [18] is recommended while the current NZ ETS price is $21.50/tonne [19] and is expected to increase to around $27/tonne in 2023 [19]. The recently published NZ Productivity Commission report [20] models three Options that estimate a carbon price ranging from $55 -$80/tonne in 2030 to $150-$250/tonne in 2050. In the EU, the traded ETS price stood at €13/tonne ($22/tonne @ 0.58 exchange rate) [21] while the EPA recommends a price of US$105 ($150/tonne @ 0.71 exchange rate) [22].

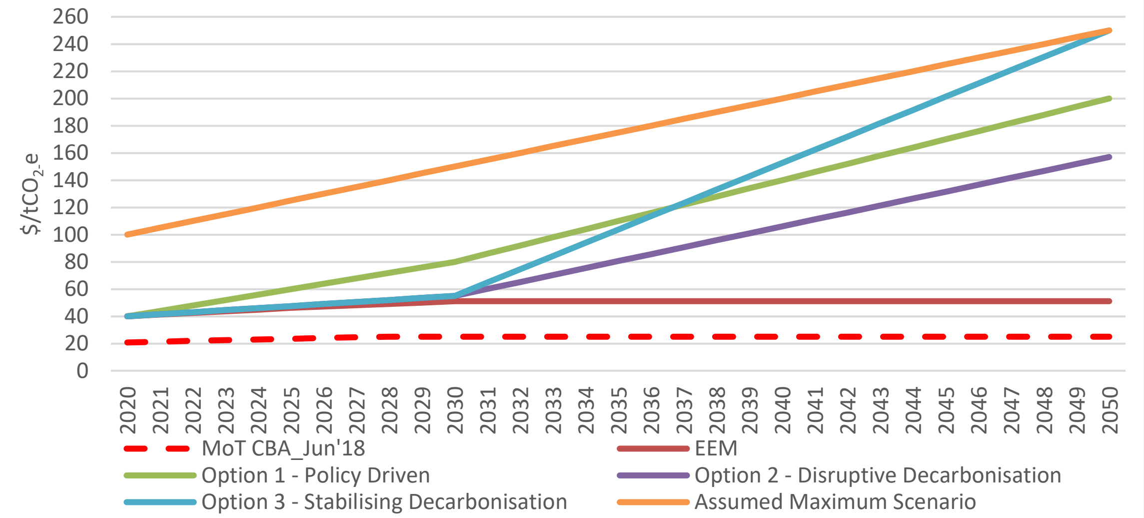
The uncertainty in the carbon price necessitates a comprehensive sensitivity analysis to determine the impact of different price scenarios on the economic indicators. The modelled social cost of carbon/carbon prices are shown in Table 14 and Figure 11.

Table 14: Comparison of different Carbon Prices and Social Cost of Carbon Values

Social cost of carbon $ per tonne of CO_2 in real terms	MoT CBA_Jun'18 (source: Mfe – 7th NC to UNFCCC)	NZTA - EEM	Prod Comm - Option 1 - Policy Driven	Prod Comm - Option 2 - Disruptive Decarbonisation	Prod Comm - Option 3 - Stabilising Decarbonisation	MoT - Assumed Scenario
2020	20.77	40.00	40.00	40.00	40.00	100.00
2021	21.38	41.23	44.00	41.50	41.50	105.00
2022	21.98	42.46	48.00	43.00	43.00	110.00
2023	22.58	43.69	52.00	44.50	44.50	115.00
2024	23.06	44.92	56.00	46.00	46.00	120.00
2025	23.55	46.15	60.00	47.50	47.50	125.00
2026	24.03	47.14	64.00	49.00	49.00	130.00
2027	24.52	48.13	68.00	50.50	50.50	135.00
2028	25.00	49.12	72.00	52.00	52.00	140.00
2029	25.00	50.11	76.00	53.50	53.50	145.00
2030	25.00	51.10	80.00	55.00	55.00	150.00
2031	25.00	51.10	86.00	60.10	64.75	155.00
2032	25.00	51.10	92.00	65.20	74.50	160.00
2033	25.00	51.10	98.00	70.30	84.25	165.00
2034	25.00	51.10	104.00	75.40	94.00	170.00
2035	25.00	51.10	110.00	80.50	103.75	175.00
2036	25.00	51.10	116.00	85.60	113.50	180.00

Social cost of carbon $ per tonne of CO_2 in real terms	MoT CBA_Jun'18 (source: Mfe – 7th NC to UNFCCC)	NZTA - EEM	Prod Comm - Option 1 - Policy Driven	Prod Comm - Option 2 - Disruptive Decarbonisation	Prod Comm - Option 3 - Stabilising Decarbonisation	MoT - Assumed Scenario
2037	25.00	51.10	122.00	90.70	123.25	185.00
2038	25.00	51.10	128.00	95.80	133.00	190.00
2039	25.00	51.10	134.00	100.90	142.75	195.00
2040	25.00	51.10	140.00	106.00	152.50	200.00
2041	25.00	51.10	146.00	111.10	162.25	205.00
2042	25.00	51.10	152.00	116.20	172.00	210.00
2043	25.00	51.10	158.00	121.30	181.75	215.00
2044	25.00	51.10	164.00	126.40	191.50	220.00
2045	25.00	51.10	170.00	131.50	201.25	225.00
2046	25.00	51.10	176.00	136.60	211.00	230.00
2047	25.00	51.10	182.00	141.70	220.75	235.00
2048	25.00	51.10	188.00	146.80	230.50	240.00
2049	25.00	51.10	194.00	151.90	240.25	245.00
2050	25.00	51.10	200.00	157.00	250.00	250.00

Figure 11: Comparison of different Carbon Prices and Social Cost of Carbon Values



The results of the sensitivity analysis indicate that the use of a higher carbon price has a moderate impact on the net benefits and a very small impact on the benefit-to-cost ratio. This is partly because of the diluting effect of discounting and partly due to the lower mitigation potential in the future due to the decreasing impact of the policy intervention itself. Table 15 below compares the results of the economic indicators from applying different carbon prices.

Table 15: Comparison of Economic Indicators from the application of different Carbon Price

	MoT CBA_Jun'18 (source: Mfe – 7th NC to UNFCCC)	NZTA - EEM	Prod Comm - Option 1 - Policy Driven	Prod Comm - Option 2 - Disruptive Decarbonisation	Prod Comm - Option 3 - Stabilising Decarbonisation	MoT - Assumed Scenario
BCR	4.21	4.35	4.45	4.36	4.36	4.81
NPV ($millions)	631.85	657.76	679.17	660.42	660.42	749.87
MAC ($/ton of CO_2)	-344	-358	-370	-359	-359	-408
CO_2 savings as a share of Net Benefits	3.0%	5.9%	8.2%	6.2%	6.2%	15.1%

Annex 7 – Additional Information on the Marginal Abatement Cost

A marginal abatement cost is a measure of the cost-effectiveness of the policy measure in reducing GHG emissions. It is calculated by dividing the net present value (NPV) of the measure with its GHG abatement potential i.e. the expected reduction in emissions that this measure would achieve if it is implemented as intended. The calculation may be shown by the following notation.

$$NPV_m = \sum_{t=0}^{n} \frac{(b-c)_{m,n}}{(1+r)} \quad (1)$$

$$MAC_m = \frac{-NPV_{m,n}}{CO_{2\ m,n}} \quad (2)$$

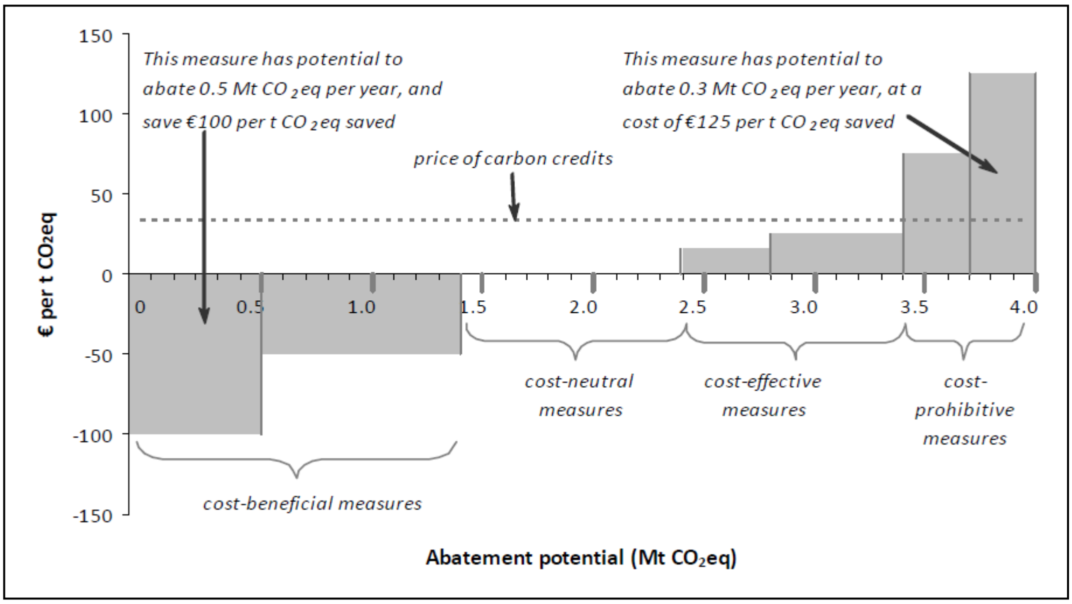
Where:

(1) NPV_m is the net present value from implementing the measure (m), b denotes the benefits derived from implementing the measure (m) whilst c denotes the costs incurred from implementing measure (m). 1+r denotes the discount rate, n represents the lifetime of measure (m) and t represents the implementation year.

(2) MAC_m is the marginal abatement cost from implementing measure (m), NPV_m is the net present value from implementing measure (m) and CO_{2m} represents the emissions in CO_2 equivalent saved from implementing measure (m) over n years.

The MAC of different measures may be ranked in ascending order from the least expensive to the most expensive in terms of GHG reductions to create a marginal abatement cost curve (MACC)[9], as stylised in Figure 12 below [23] [24].

Figure 12: Stylised Marginal Abatement Cost Curve



[9] A MACC represents the relationship between the quantity of abated emissions and the [incremental] price of CO_2 through the implementation of abatement measures.

The 'low hanging fruit' are those measures on the left hand side and below the horizontal axis since these measures are both financially worthwhile[10] and save emissions. Moving to the right of the horizontal axis would represent more costly measures. To determine which of the measures situated above the horizontal axis are still worthwhile to implement, a 'social cost of carbon' (SCC) is used as a benchmark [25]. Any measure whose bar is higher than the SCC line would be deemed to be too expensive to undertake and, in theory, it would therefore be cheaper to buy carbon allowances.

The total cost and emissions savings from the implementation of the measures are based on a number of underlying assumptions, including the emissions reduction potential, the behavioural changes that the measure might induce and the time period over which it would be effective. For example, an energy saving awareness campaign may be expected to induce a behavioural change in 10% of households which would subsequently reduce their energy consumption (and hence emissions) by 1% per year over the next 5 years. These assumptions are therefore crucial to obtain a meaningful MAC and a careful analysis is required when calculating the emissions saving potential and the cost of each measure. These estimations need to be sufficiently robust in the face of the uncertainties inherent in any analysis that requires some form of projections.

Moreover, the measures being considered are likely to have an impact on one, or more, of the other measures. These multi-measure interactions can be quite complex and it may be difficult to assess their overall effect. Hence, a careful examination of these interactions is required and detailed caveats would have to be made when drawing conclusions through the use of the bottom-up approach.

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[10] As denoted by a positive NPV

Annex 8 – Contribution to New Zealand's GHG Emissions Reduction Targets

In 2020, the projected emissions from road transport are expected to reach 14.1 million tonnes of CO_2 equivalent with 8.5 million tonnes of CO_2 equivalent emitted by cars, SUVs and light trucks. The latter are projected to decrease to 7.1 million tonnes of CO_2 equivalent in 2040 under the most conservative scenario[11] [6].

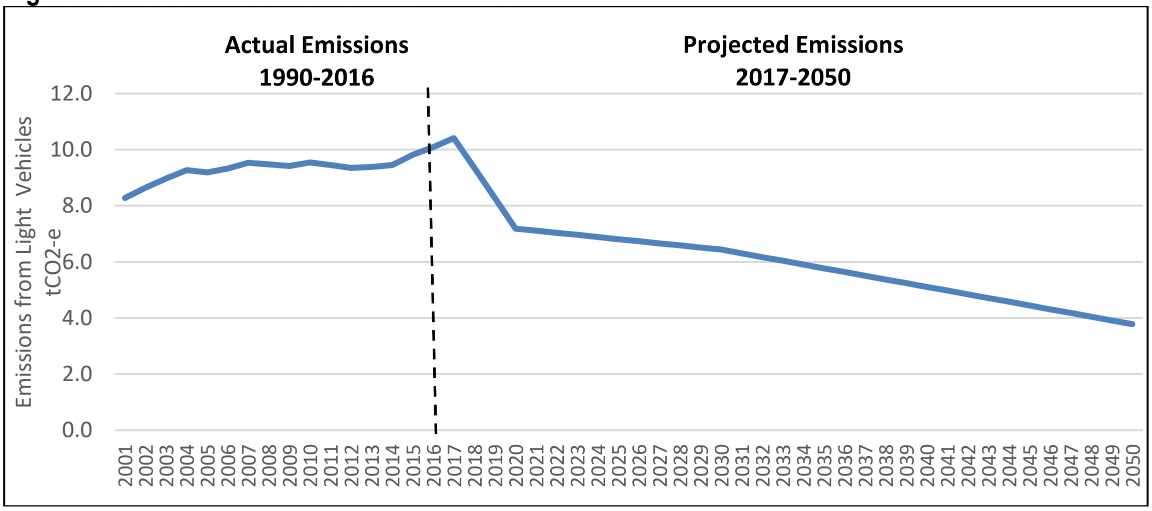
New Zealand's current GHG reduction targets [22] apply at the national level and are not sector-specific. Hence, there is no specific target for the transport sector. The GHG reduction targets are the following:

(1) 5% below 1990 levels by 2020
(2) 30% below 2005 levels by 2030 (equivalent to 11% below 1990 levels)
(3) 50% below 1990 by 2050

For the purposes of this analysis, these national level targets were applied to the road transport emissions[12] and a target trajectory was calculated for the period 2020 to 2050. A linear interpolation was used to obtain annual figures for the interim years.

To obtain a comprehensive time series of historic and projected emissions specifically from light vehicles, the historic emissions (2001-2016) from light vehicles were included with the target trajectory (2017-2050). These historic emissions were obtained from the National Inventory Submission under the Common Reporting Framework (CRF) as reported to the United Nations Framework Convention on Climate Change (UNFCCC) [23]. The resultant time series of road emissions covering 2001-2050 is shown in Figure 13.

Figure 13: Road Emissions from 2001 – 2050

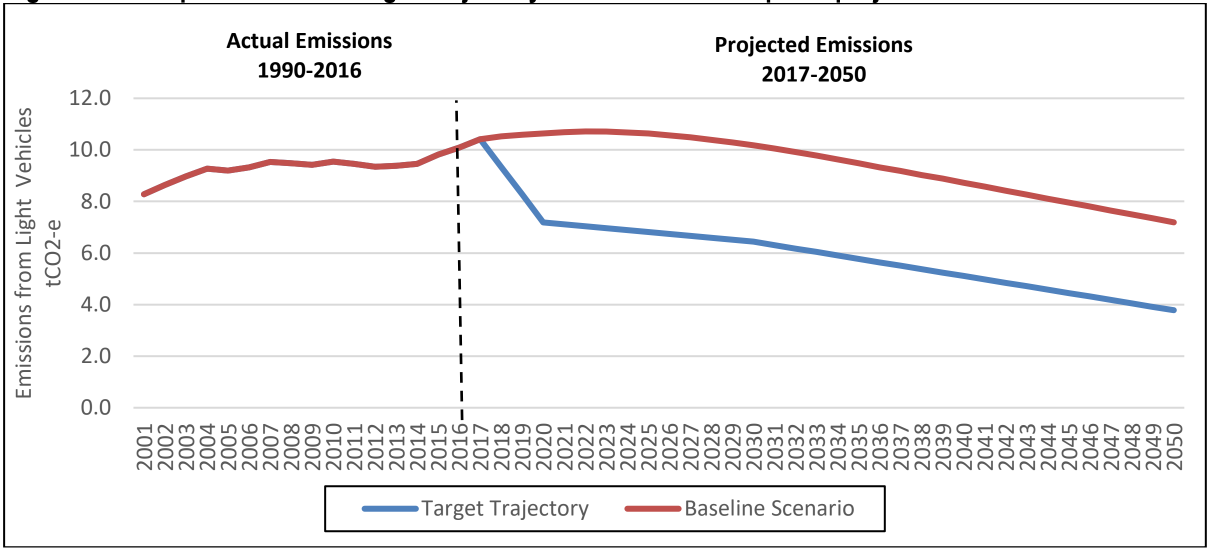


source: [6], [23]

Superimposing the projected emissions from light vehicles as estimated in the VFEM's Slow EV Uptake scenario [3] shows the 'target gap' between the projected scenario and the target trajectory. This gap therefore shows where New Zealand is expected to stand in relation to its GHG reduction targets at any given year and the effort needed to attain these targets. Figure 14 below compares the target trajectory with the Slow EV Uptake scenario.

[11] The MoT models a number of scenarios in the Future Outlook report. The most conservative is the 'Slow EV Uptake' scenario, which assumes a quasi-linear uptake in electric vehicles for the period 2020-2040.
[12] In theory, a sector-specific target should be based on the cost-effective mitigation potential of the particular sector.

Figure 14: Comparison of the Target Trajectory with the Slow EV Uptake projections



The annual CO_2 savings from the feebates scheme are compared with both the emissions projections and with the observed target gap. In the latter case, this comparison provides an indication of how much this measure can contribute to help New Zealand remain within its annual carbon budget. Table 16 shows the contribution from the annual CO_2 savings from the feebate scheme at the end of each decade. The year 2026 was included because the annual CO_2 savings from the feebate scheme are at their highest in that year.

Table 16: Contribution to Target Trajectory and Target Gap

	Emissions from Light Vehicles (A)	Target Trajectory (B)	Target Gap (C = A - B)	Difference between Gap and Trajectory (C)/(B)	Annual Emissions Savings (D)	Share of Emissions Savings from Light Vehicles emissions (D)/(A)	Share of Emissions Savings from Target Gap (D)/(C)
	MtCO2-e	MtCO2-e	MtCO2-e		MtCO2-e		
2020	10.64	7.19	3.45	48%	-	-	-
2026	10.56	6.74	3.83	57%	0.12	1.1%	3.15%
2030	10.17	6.44	3.74	58%	0.13	1.3%	3.51%
2040	8.72	5.11	3.61	71%	0.02	0.3%	0.66%

Table 16 shows that the feebates scheme would reduce the projected emissions from light vehicles by 1.1% in 2026. This figure falls to 0.3% by 2040 in-line with the decreasing impact of the feebates scheme on the imported vehicles i.e. in that year, most of the imported vehicles would already have low average emissions, and hence, the impact of the measure will be much lower. Expressing these savings in terms of the target gap, the feebates scheme would reduce the gap by 3.1% in 2026 and decreasing to 0.6% in 2040.

Annex 9 – Equivalent Value of the Cumulative Emissions Savings

An 'equivalent value' compares the emissions savings from implementing a GHG reduction measure with an equivalent source that would need to be reduced or to an equivalent sink that would need to be introduced to offset the CO_2 emissions. This comparative exercise provides a sense of the scale of CO_2 savings from implementing a GHG reduction measure. In this analysis, the CO_2 savings are compared to the following equivalent sources or sinks:

(1) Power stations that would be taken off-line
(2) Vehicles that would be scrapped or lifetime emissions from the three most popular vehicles
(3) Trees that would be planted

Power stations taken off-line

The Ministry for Business, Innovation & Employment (MBIE) reports the GHG emissions from the energy sector [28] on an annual basis. A subset of this sector is electricity generation and the annual GHG emissions for 2011 to 2015 are shown in Table 17.

Table 17: GHG emissions from electricity generation

	kt CO2-e
2011	5,012
2012	6,417
2013	5,198
2014	4,231
2015	4,041

The feebates scheme is expected to save 1.5 million tonnes of CO_2 equivalent over its lifetime and therefore, it is equivalent to preventing 5 months worth of emissions that occur from electricity generation. A similar comparison with a 'standard' power station indicates that the CO_2 savings are approximately equivalent to:

- **2 years** of emissions from a large (400MW) efficient gas-fired power station operating for most of each year or;
- **5 months** of emissions from a large (750MW) coal fired power station operating for most of the year.

Vehicles that would be scrapped

A preliminary CBA carried out by the MoT on the implementation of a vehicle scrappage scheme in Auckland indicates that, on average, scrapping a vehicle (between 10 to 18 years) would save approximately 10.9 tonnes of CO_2 per vehicle (weighted by the level of travel to be expected by vehicle age over the remaining economic life time of the vehicle). This figure is based on a number of assumptions including the characteristics (age, fuel type, emissions rating etc.) of the scrapped vehicles. In general, these where based on historic data on the types of vehicles scrapped.

The feebates scheme is expected to save 1.5 million tonnes of CO_2 equivalent. The estimated CO_2 savings is therefore equivalent to scrapping 142,000 vehicles between 10 and 18 years of age from the existing fleet (excluding the emission effects from the purchase of any replacement vehicles).

Another approach is to base the equivalent value on the number of new vehicles that are imported in New Zealand. In 2017, the three most popular vehicles were the Ford Ranger, Toyota Hilux and Holden Colorado [4]. Their average emissions range from 191 gCO_2/km for a single cab to 223 gCO_2/km for a double cab. Taking the average of these two figures and the total VKT driven over their economic lifetime (17 years), the CO_2 savings from the feebates scheme would be equivalent to lifetime emissions from 60,000 such vehicles.

Trees that would need to be planted

A report published by the Parliamentary Commissioner for the Environment [29] indicates that a hectare of pine trees would offset 31 tonnes of CO_2 emissions per year in the first 20 years of the tree's life. To retain the storage of 600 tonnes of CO_2 per hectare, the rotations need to continue indefinitely or an equivalent area will need to be planted. A hectare of pine trees can accommodate between 1,000 to 2,500 individual trees, depending on the number of rows and spacing in-between these rows, amongst others. The annualised savings from the feebates are expected to be 83,500 tons of CO_2 equivalent, and hence, these savings are equivalent to planting around 2.2 million trees every 20 years. This is equivalent to planting an area of 22 square kilometres (if a spacing of 1000 trees per hectare is assumed), which is roughly the size of Kapiti Island.

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