House View
Long Term Liquid Fuel Demand

6 August 2021

Disclaimer

Please read this page before the rest of the presentation

Please do not read this presentation in isolation

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Agenda

1. Introduction
2. Model overview
3. Model logic detail
4. Outputs
5. Our view of key drivers

How the model works

What is the distance from A to B, how do we get there, and therefore how much fuel is required?

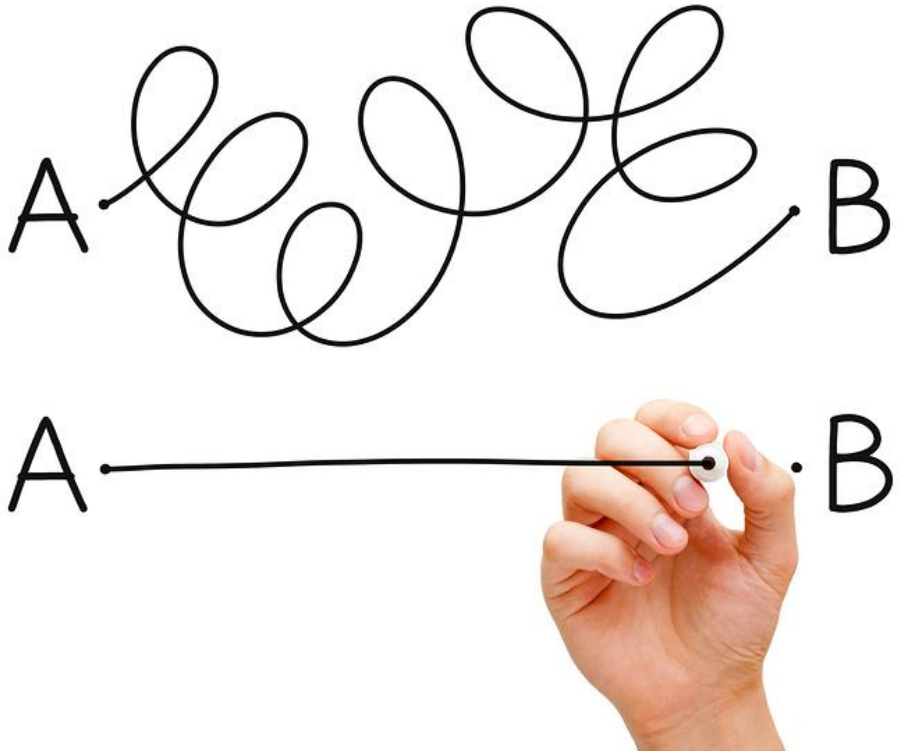
Bottom-up calculation of fuel demand

The model is a sophisticated and complex tool, designed to estimate the total demand of land transport in litres using several bottom-up drivers. However, in simple terms it is essentially trying to answer three key questions:

Key question	Description	Underlying drivers[1]
1. What is the total land **transport task** for New Zealand?	*How far do we need to travel in each year?* *Measured in KMs (Vehicle Kilometres Travelled, VKTs)*	• *Population, location and demographics* • *Economic activity (GDP)* • *Consumer preference (e.g. public transport)* • *Infrastructure and option availability*
2. How will the transport task be **delivered**? *The model uses 'Bass Diffusion' to forecast EV adoption rate as the technology diffuses through the market. Bass Diffusion is described further under supporting information*	*What is the split of household movements by transport mode (modal shift)?* *What is the vehicle fleet composition and how does that vary by vehicle type / size?*	• *Cost differentials between ICE and EVs* • *Time technology has been available (adoption rate)* • *Government policies (e.g. mandates, subsidies)* • *Consumer preferences* • *Ease of use* • *Accessibility*
3. What is the resulting **fuel requirement**?	*How much fuel is required to deliver the transport task using these modes of transport?*	• *Vehicle fuel efficiency* • *Technology*

Government Policies

The model also contains functionality to simulate certain government policies, such as import bans on ICE vehicles, feebate/rebate schemes and biofuels mandates.



[1] Explicit key drivers in the model are highlighted in light blue. Other drivers are included in CCC's underlying assumptions, which are incorporated into the underlying VKTs.

1. What is the Total Transport Task?

Household transport

Comments

- The Model uses CCC's data (Demonstration Scenario) to estimate total Vehicle-Kilometres Travelled (VKTs), split by Vehicle type.
- Population growth is the key driver of overall growth in VKTs.
- Over the last 20 years, VKT per capita for LPVs has been pretty steady at around 7,000 VKTs per capita, which we expect to continue.
- Mode shift away from vehicles to Public Transport or 'active' travel is the other key driver.
- We believe that mode shift will not be as significant as the CCC forecasts; we believe local governments and NZTA will struggle to invest sufficiently to re-engineer public transport, walking and cycling infrastructure.

	2011	2016	2021	2025	2030	2035	2040
Household VKTs (mil)							
Light Passenger	30,723	33,902	35,542	37,723	40,187	41,464	41,856
Light Commercial	6,181	8,427	9,745	10,281	10,431	10,417	10,369
Motorcycles	381	419	413	460	467	461	448
Buses	230	274	334	417	523	607	684
Population (mil)	**4.39**	**4.69**	**5.07**	**5.29**	**5.54**	**5.72**	**5.88**
VKTs per capita							
Light Passenger	*7,001*	*7,227*	*7,015*	*7,125*	*7,251*	*7,247*	*7,119*
Light Commercial	*1,408*	*1,796*	*1,923*	*1,942*	*1,882*	*1,821*	*1,764*
Motorcycles	*87*	*89*	*82*	*87*	*84*	*81*	*76*
Buses	*53*	*58*	*66*	*79*	*94*	*106*	*116*
Mode share							
LPVs %	*94.5%*	*94.5%*	*94.0%*	*92.9%*	*90.7%*	*88.5%*	*86.4%*
PT %	*3.3%*	*3.3%*	*3.8%*	*4.4%*	*5.7%*	*6.7%*	*7.8%*
Active %	*2.2%*	*2.2%*	*2.2%*	*2.3%*	*2.7%*	*3.3%*	*5.8%*

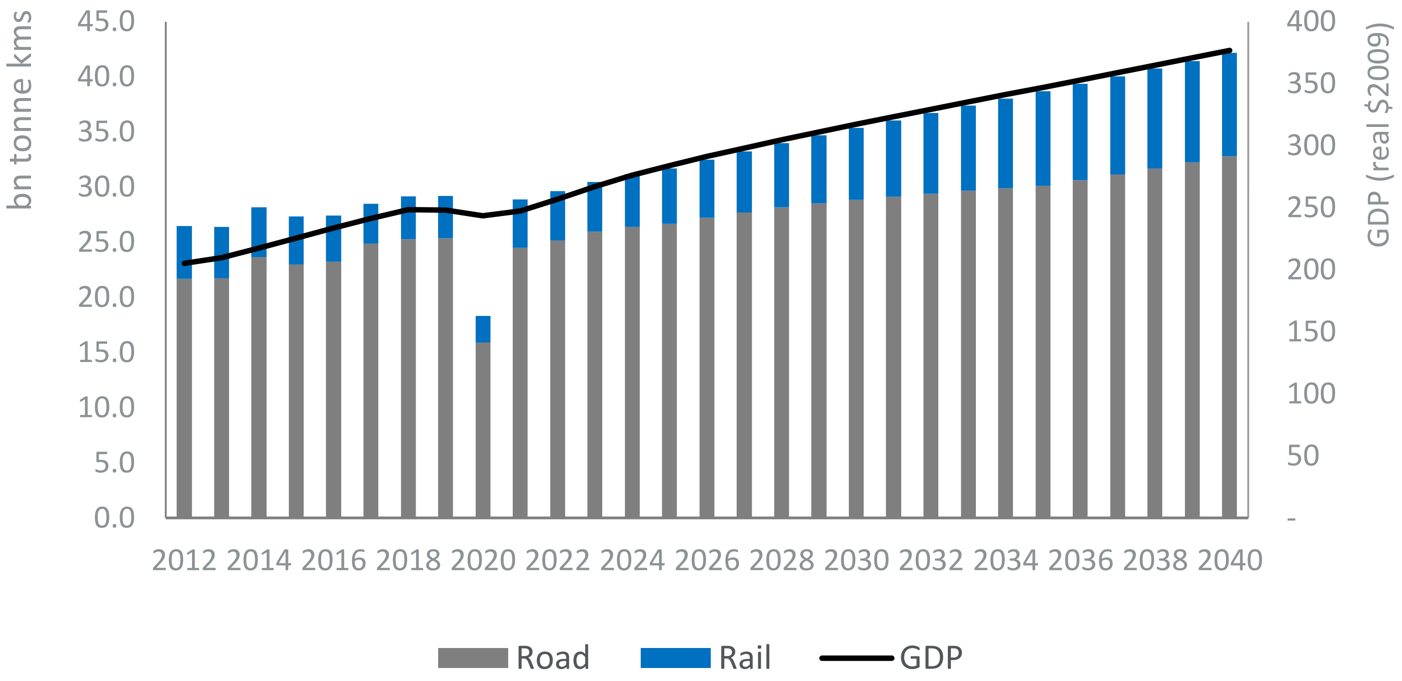
Source: CCC - Demonstration Path scenario, Castalia Analysis

1. What is the Total Transport Task?

Freight transport – Road (Medium and Heavy Trucks) vs Rail

- Freight transport accounts for a material portion of total land diesel demand, estimated at around 55% to 60% (trucks and rail).
- The Model estimates the total Freight Task ('Tonne Kilometres') of Road and Rail transport using a relationship to GDP.
- The ratio of TKM:GDP continues the recent minor decreasing trend in the first 5 years, then remains flat thereafter.
- The same modal shift to rail is applied in the Model as the CCC's Demonstration Path, with Rail's share of land freight increasing from 13% to around 22%.

Freight task



2. How will the Transport Task be Delivered?

Forecasting EV Adoption - Bass Diffusion Model

Bass Diffusion Model

- Popular approach in modelling technological adoption, used extensively in literature and product research.
- The Bass model assumes that potential buyers of an innovation can be divided into two groups:

1. Innovators: People who buy the product first and are influenced only by ‘external communication’ e.g. mass media or advertisement.
2. Imitators: Individuals who, in contrast, buy if others have already bought the product since they are influenced by word of mouth or so-called ‘internal communication’

- Castalia have implemented a ‘Modified Bass Diffusion Model’, using the below formula:

EV inflows per year

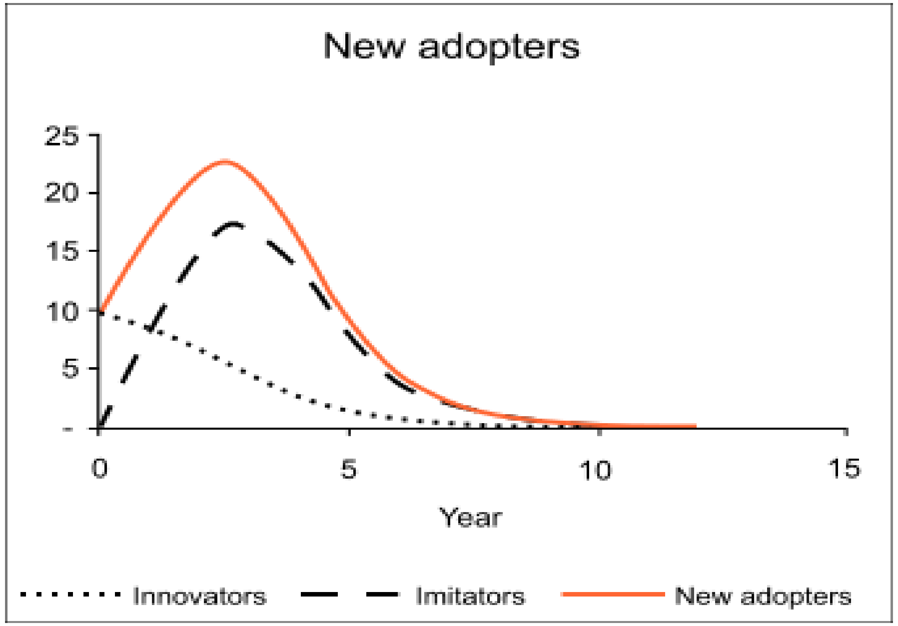
$$Inflow(t) = A_t \left[\frac{1 - e^{-(p+q)M(t)}}{1 + \frac{q}{p} e^{-(p+q)M(t)}} \right]$$

Mapping function $M(t)$

$$M(t) = e^{C_t} + e^{C_{t-1}}$$

Variables

$A_t =$	Total vehicle inflows in a given year
$p =$	Innovation factor. Estimated from the literature.
$q =$	Imitation factor (Word of mouth). Estimated from the literature.
$t =$	Projection period
$C_t =$	Cost difference between ICE and EVs, expressed as a % of total ICE cost.



2. How will the Transport Task be Delivered?

Total fleet size and composition

- The Bass Diffusion Model estimates the proportion of **vehicle inflows** that will be EVs.
- The other part of the puzzle is the total fleet size and how this changes over time.

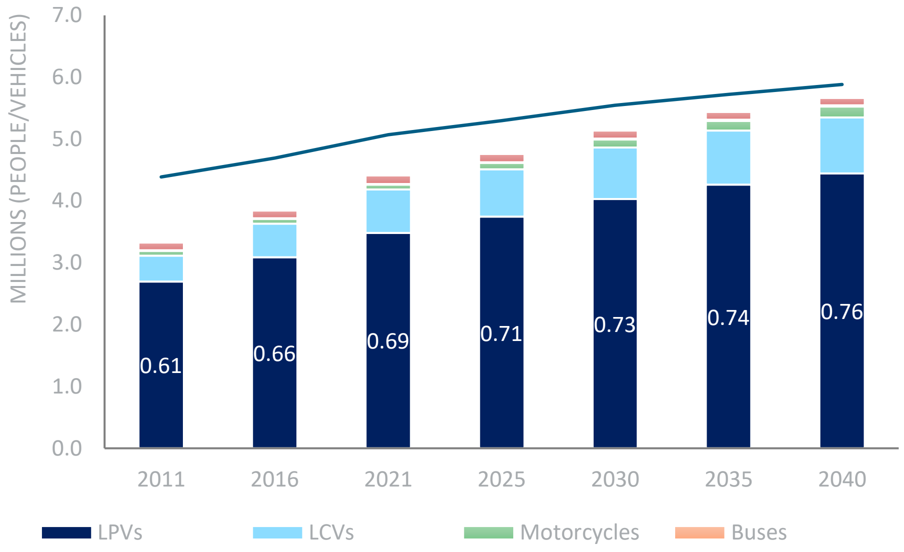
Fleet size and composition

- The fleet is modelled using the formula (for each vehicle type and engine type):

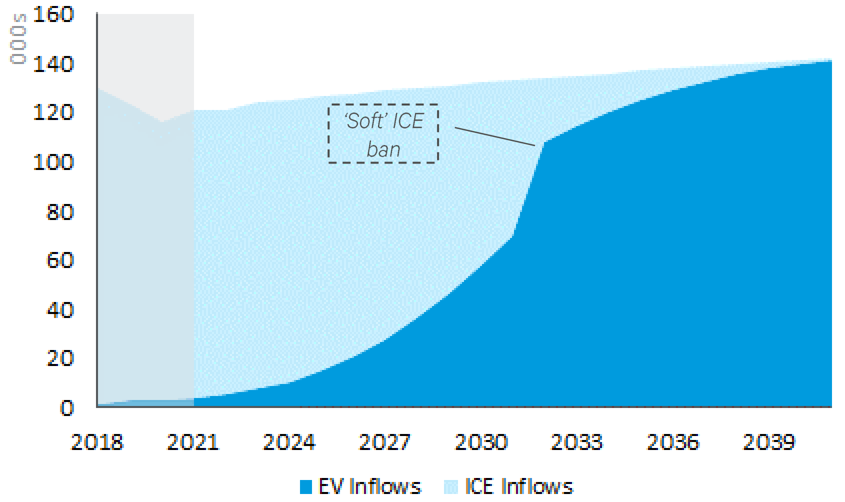
  Vehicle fleet closing stock = opening stock + inflows – disposals

- **Inflows** are estimated based on the average of the last two years' inflows, increasing at the rate of GDP growth.
- **Disposals** are estimated using an annual disposal factor of 6%, applied to the cumulative inflows over the vehicle's expected lifetime.

Forecast fleet numbers vs population



Annual Vehicle Inflows: New LPVs



3. What is the resulting fuel requirement?

- With the Transport Task estimated (kms per vehicle), and the allocation of these VKTs to vehicle types and engine types, the fuel demand is then calculated using the formula:

$$[Fuel]_t^i = [VKT]_t^i \times [FCF]_t^i \times [Fuel\ \%]_t^i$$

$Fuel =$ Total demand for premium, regular or diesel fuel (litres)
$VKT =$ Total vehicle kilometres (KMs)
$FCF =$ Aggregate fuel consumption factor (litres/KM)
$Fuel\ \% =$ Premium, regular and diesel share of total fuel consumed.

- The Fuel Consumption Factor declines over time as technology improves (refer chart opposite).

Vehicle efficiency

Figure 8.15 shows the assumed changes in emissions per kilometre travelled by internal combustion vehicles for the two classes of light vehicles: light passenger vehicles (cars/SUVs) and light commercial vehicles (vans/utes). The assumed emissions per vehicle-kilometre are the same in all scenarios with a modest improvement over time. The assumed efficiency improvements account for the increased adoption of conventional hybrid vehicles. Although conventional hybrid vehicles are at least partly powered by electric motors, they are still internal combustion engine vehicles as their batteries cannot be charged from the grid.

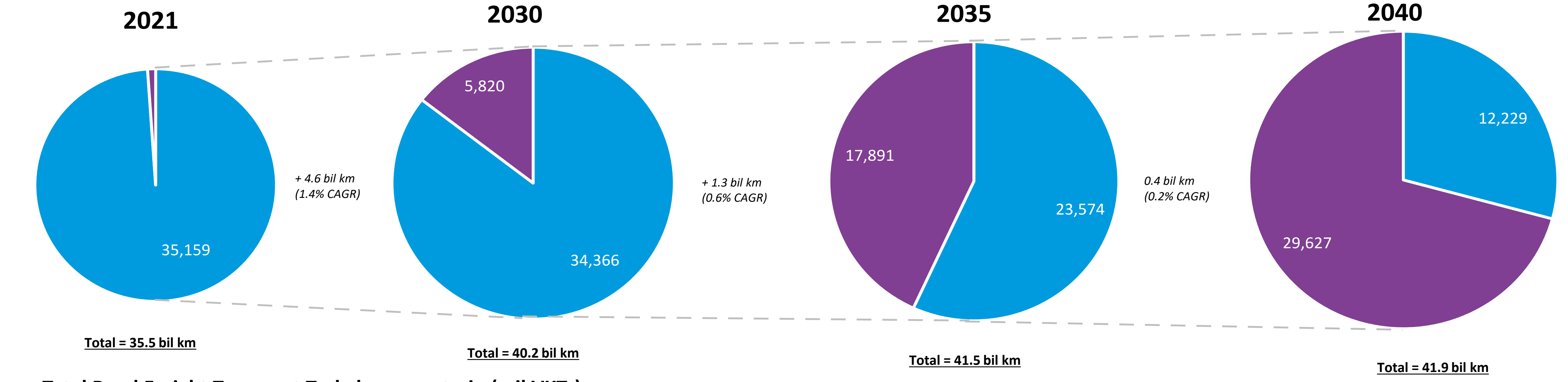
Figure 8.15: Emissions per vehicle kilometre travelled by internal combustion vehicles

Source: Commission analysis.

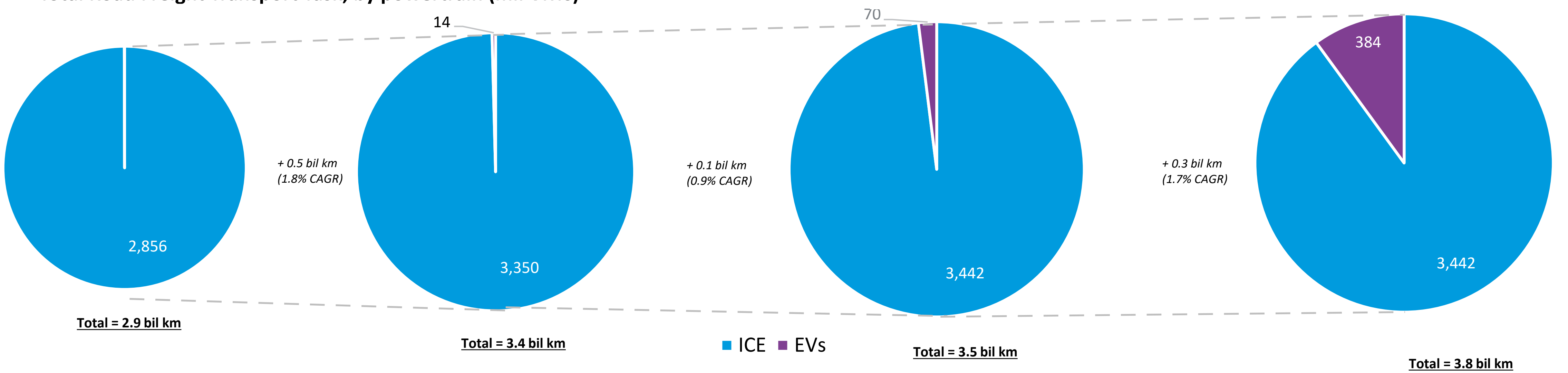
Results: size and delivery of total transport task

Population and economic growth is expected to continue to drive growth in the total 'transport task' over the next 20 years, despite increasing modal shift driven by policy and infrastructure investment

Total Light Passenger Vehicle Transport Task, by powertrain (mil VKTs)

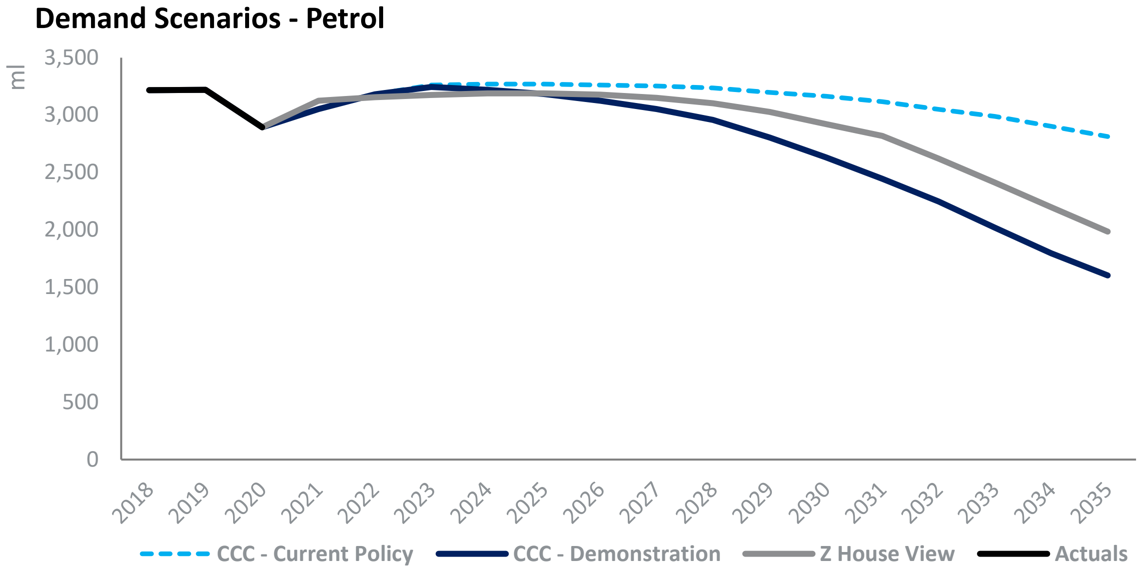


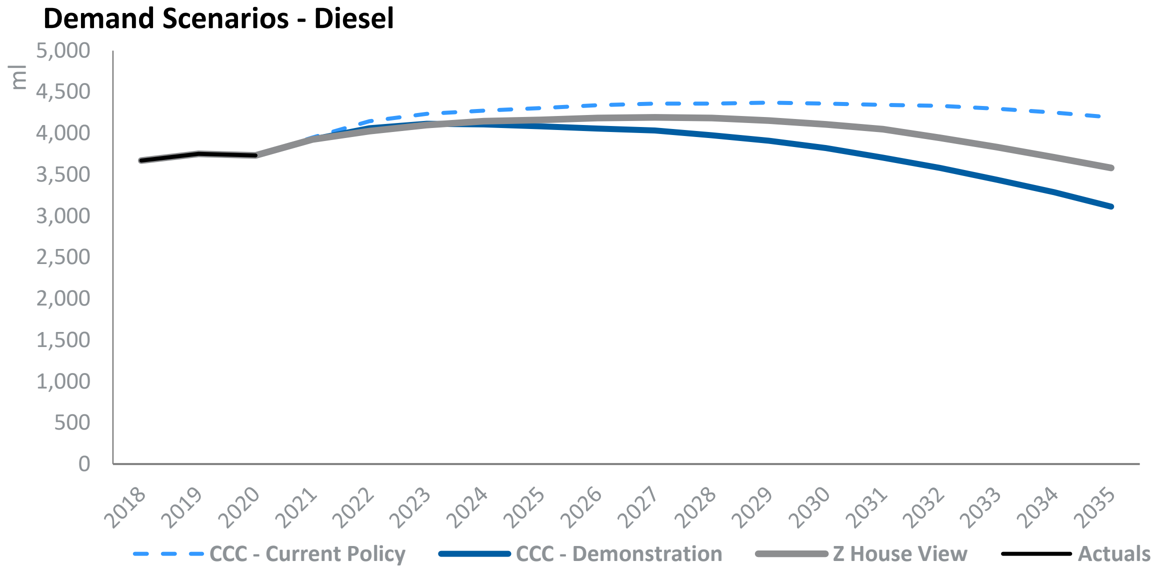
Total Road Freight Transport Task, by powertrain (mil VKTs)



Summary results to 2035: comparison to CCC

While using the majority of the CCC's underlying assumptions, Z's House View differs in some areas





Key drivers of the difference relative to CCC Demonstration Path Scenario include:

1. Slower EV uptake, due to not adopting a strict ban on ICE vehicles and a different EV adoption methodology, despite assuming a slightly faster path to EV:ICE cost parity.
2. By 2035, Z has assumed the average EV will travel up to 30% further than ICE vehicles; CCC's modelling implies the average EV will travel up to 46% further.

LPVs (2035)	1. LPV Fleet Share		2. LPV VKTs/Vehicle	
	Z	CCC	Z	CCC
ICE	63.4%	57.8%	8,719	9,571
EVs	36.6%	38.1%	11,491	13,964
Average			**9,733**	**11,243**

Key drivers of the difference relative to CCC Demonstration Path Scenario include:

1. The overall freight transport task materially higher in Z's house view. We have assumed a relatively constant relationship with forecast GDP, and the same rail modal shift as CCC. CCC's forecast freight transport task appears to imply a 'decoupling' of this relationship to GDP.
2. Lower truck EV uptake, due to different EV adoption methodology.
3. By 2035, Z has assumed the average EV truck will travel up to 9% further than ICE vehicles; CCC's modelling implies the average EV truck will travel up to 300% further.

Truck fleet (2035)	1. Freight VKTs (bn km)		2. Truck Fleet Share		3. HT VKTs/Vehicle	
	Z	CCC	Z	CCC	Z	CCC
ICE	3.39	2.05	96.6%	85.4%	50,290	52,024
EVs	0.12	0.86	3.4%	14.6%	54,892	156,344
Total/Average	**3.51**	**2.91**			**50,385**	**56,728**

Drivers of transport fuel demand in NZ

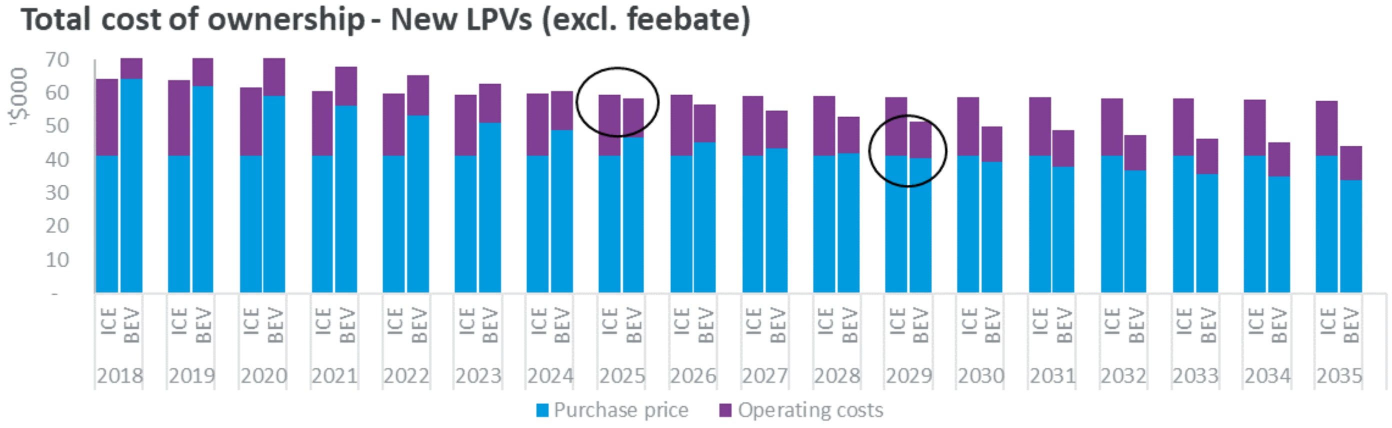
Policy updates could shift provisional house view, particularly mode shift and ICE ban

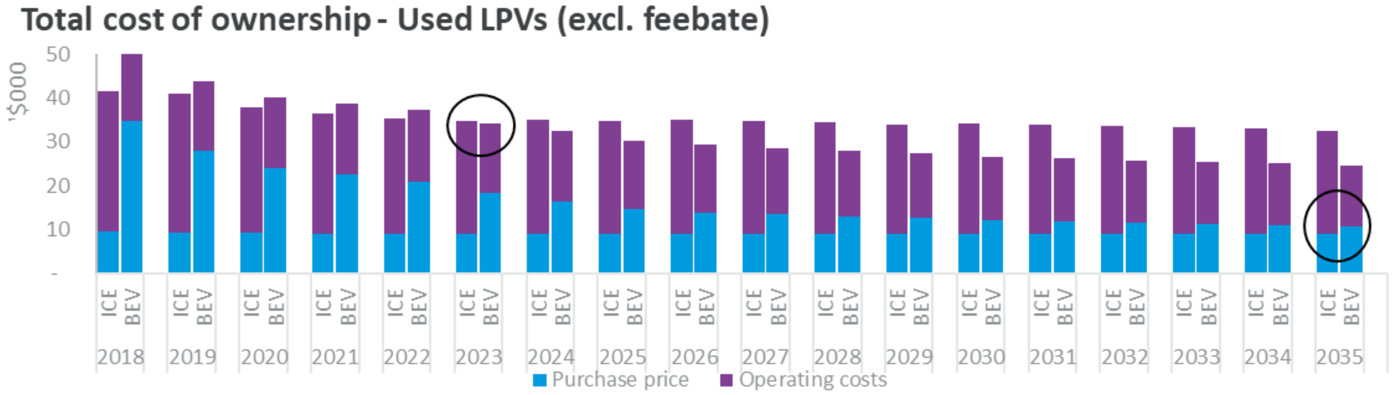
NO	KEY DRIVER	RELATIVE POSITION	Z VIEW	CHANGE TYPE	IMPACT ON 2035 FUEL DEMAND
1	EV/Battery price path	*Faster than CCC*	*LPV capital cost parity 1 year earlier vs CCC (excl. feebate) (2031 -> 2030)*	Modelling	↓ ***Petrol: -15ml, -0.8%*** ***Diesel: -10ml, -0.3%***
2	Climate change policy for transport	Slower than CCC	*i. No hard ICE Light Vehicle ban. ('Soft' ban of 50% of residual sales applied from 2032).*	Policy View	↑ ***Petrol: +110ml, +5%*** ***Diesel: +60ml, +1.5%***
		Included feebate (CCC did not include)	*ii. Feebate modelled over 2022 – 2028, with declining rebates for EVs over time and approximate fiscal neutrality over the life of the scheme. LPV capital cost parity occurs ~2023 (inclusive of driver #1 and #4)*	Policy View	↓ ***Petrol: -80ml, -4.0%*** ***Diesel: -35ml, -1.0%***
3	Adoption of EVs	Slower than CCC	Bass diffusion vs CCC EV uptake *(2035 LPV Fleet EV: 37% vs 38%, Truck Fleet EV: 3.4% vs 14.6%)*	Modelling	↑ ***Petrol: 80ml, -4%*** ***Diesel: 400ml, -11%***
4	NZ vehicle market EV pricing and availability	Better than CCC	LPV capital cost parity additional 1 year earlier vs CCC (excl. feebate) *(2030 -> 2029)*	Modelling	↓ ***Petrol: -15ml, -0.8%*** ***Diesel: -10ml, -0.3%***
5	Fuel/electricity pricing and taxes	Fuel more expensive	CCC keeps fuel prices flat from 2023 House view :+5cpl 2026 +10cpl 2030	Modelling	↓ ***Petrol: -10ml, -0.5%*** ***Diesel: -10ml, -0.3%***
6	Fuel efficiency standards/vehicle improvement	Same as CCC	None	None	***None***
7	GDP and population growth	Same as CCC	None	None	***None***
8	Freight task (Tonne KMs)	Higher than CCC	Heavy vehicles: 3.5 billion VKTs vs 2.9 bn VKT for CCC	Modelling	↑ ***Petrol: 0ml, 0%*** ***Diesel: +390ml, +11%***
9	Transport patterns - VKT/person, mode shift	Less mode shift than CCC	Reduced CCC's rate of mode shift by 1/3, following Auckland Transport's assessment of what is achievable	Policy View	↑ ***Petrol: +80ml, +4%*** ↓ ***Diesel: -30ml, -1%***
10	Relative vehicle utilisation of early EV adopters	Less than CCC	EV LPVs travel up to 30% further than ICE; CCC's 46% further. EV truck travel up to 9% further than ICE vehicles; CCC's up to 300% further.	Modelling	↑ ***Petrol: +100ml, +5%*** ***Diesel: +280ml, +8%***
11	Off-road diesel demand profile relative to on-road transport	Z: Same speed CCC: Slower	Z House View assumes same rate of change as on-road, while the CCC's assumes off-road demand will decline at a materially slower rate than it's on-road transport profile	Modelling	↑ ***Petrol: +0ml, +0%*** ***Diesel: +50ml, +1.5%***

Questions

Appendix: Forecast cost curves

TCO Comparison (LPVs)





- The charts opposite use CCC's forecast capital cost curve, adjusted per slide 11 (capital cost parity of new EVs expected to happen 2 years earlier).
- The charts exclude the impact of the feebate.
- Our Model applies the feebate using the government's stated fee / rebate amounts in early years, with the amounts adjusted over time to result in a revenue-neutral policy.

Appendix: Forecast cost curves

TCO Comparison (Trucks)