Public Transport Operating Model (PTOM) Decarbonisation Option Development

Ministry of Transport

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kpmg.com/nz

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25 June 2020

Review of New Zealand's urban bus fleet

Dear Tim

Thank you for the opportunity to support the Ministry of Transport (the "Ministry" or "MoT") in its review of options for the decarbonisation of New Zealand's urban bus fleet.

Our work has been performed in line with the scope of our All of Government Consultancy Services Order (CSO) and is based on information provided by the Ministry or collected through our desk-top research and interviews with other jurisdictions.

We have not engaged with key New Zealand stakeholders, such as bus operators and regional councils, because they have other priorities currently with the COVID-19 response. We recommend the options presented in this report are tested further with stakeholders prior to drawing any conclusions and we understand this is the Ministry's intention.

Please don't hesitate to contact me if you have any questions.

Kind regards,

Stephanie Ward

Inherent Limitations

This report has been prepared in accordance with our CSO dated 12 March 2020 (the "Engagement Letter"). Unless stated otherwise in the Engagement Letter, this report is not to be shared with third parties. However, we are aware that you may wish to disclose to central government agencies and/or relevant Ministers offices elements of any report we provide to you under the terms of this engagement. In this event, we will not require the relevant agencies or Ministers' offices to sign any separate waivers. We also note MoT's requirements under the Official Information Act.

The services provided under our engagement letter ('Services') have not been undertaken in accordance with any auditing, review or assurance standards. The term "Audit/Review" used in this report does not relate to an Audit/Review as defined under professional assurance standards.

The information presented in this report is based on data and information made available to us in the course of our work (particularly from MoT) and publicly available information. We have indicated within this report the sources of the information provided. Unless otherwise stated in this report, we have relied upon the truth, accuracy and completeness of any information provided or made available to us in connection with the Services without independently verifying it.

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This report is solely for the purpose set out in Section A "Background and Scope" of this report and for MoT information, and is not to be used for any other purpose or copied, distributed or quoted whether in whole or in part to any other party without KPMG's prior written consent (aside from as provided for above with regards to central government agencies and Ministers' offices).

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Additionally, we reserve the right but not the obligation to update our report or to revise the information contained therein because of events and transactions occurring subsequent to the date of this report.

Contents

A

Background

Background and Scope

Background

New Zealand provides public transport services in its major cities and a number of its smaller towns, with buses the predominant form. Across the country there are c118 million annual bus journeys, which is c75% of the total public transport journeys nationwide.

Regional councils and in Auckland, Auckland Transport, are responsible for the delivery of public transport in their region and will contract a variety of operators (mostly private sector) to deliver services under the Public Transport Operating Model ("PTOM"). The services are co-funded by the Councils and Waka Kotahi New Zealand Transport Authority ("Waka Kotahi" or "NZTA").

Strategic Case

New Zealand's public transport bus fleet is large, comprising over 2,500 vehicles. These are predominately owned by the bus operators.

Despite the scale of the fleet, New Zealand has limited adoption of Zero Carbon Technology buses with c98% of buses in operation still running on diesel technology.

While some organic transition to Zero Carbon Technologies is evident, without some form of positive intervention we are unlikely to see widescale adoption of Zero Carbon Technologies in the near future.

We understand that as part of wider environmental and sustainability ambitions, the Ministry of Transport (the "Ministry") is looking at ways the New Zealand urban public transport bus fleet can achieve full transition to Zero Carbon Technologies within the next 20 years.

To assist with achieving this goal, the Ministry would like to develop a set of options to implement a new Zero Carbon Technology fleet considering various ownership, procurement, contractual, timing and funding structures.

While the long-term aim is to achieve this across the country, this report will focus on the development of options for Auckland, Wellington and Christchurch.

Scope and approach

KPMG, assisted by Mott MacDonald, has been asked to support the Ministry to develop options for increasing the use of Zero Carbon Technologies in buses.

We first sought to understand the current hurdles to transitioning the fleet and then developed a long list of options that may address these, with a focus on procurement, ownership, timing, contractual structures and funding.

We then considered the implications of the options, drawing on case studies from other jurisdictions where possible.

Due to timeframes and the impact of COVID-19, it has not been possible to engage with New Zealand stakeholders to test the options further, however where possible we have used publicly available information and have spoken to other jurisdictions to learn lessons from their zero carbon bus initiatives.

We understand that as a next step the Ministry intends to develop a policy options paper and engage with councils and bus operators.

It is important to note that this report is an option development exercise rather than a procurement or viability assessment. While there may be some similarities of terminology, this is for convenience only and the options developed are intended to be dynamic and flexible.

This report first sets out the barriers to widespread adoption of Zero Carbon Technologies under the current market settings. It then reviews the potential Zero Carbon Technologies available and then considers the options for implementation from various viewpoints (e.g. procurement and ownership, timing, funding). Finally, it draws together emerging themes and next steps.

Barriers to widespread adoption

The New Zealand Government views the transition to a Zero Carbon fleet in 20 years as a priority. While this view aligns with the priority of many Regional Councils and operators, we have identified a number of significant barriers that prevent the organic transition to Zero Carbon Technology.

Infrastructure and cost

— The high upfront cost of supporting infrastructure (e.g. charging stations, substations, backup generators), including the upgrade of power (or alternative) energy networks, in and outside of depots, along with the development of energy management systems. Estimated upfront capital cost for a single battery electric bus is cNZD750,000 vs diesel cNZD420,000 with charging units costing cNZD70,000 per 80kW charger. Reinforcement and grid transmission upgrade costs vary significantly and are highly dependent on scale and site location. Please refer Appendix 1 for example of resilient network.

— The increased demand on depot floorspace due to the additional charging infrastructure required to power and operate Zero Carbon Technology buses.

— The economies of scale needed before savings (e.g. reduced fuel requirement) from operating Zero Carbon Technology buses can be achieved by operators (this is due to large upfront capital cost required to purchase new fleet and supporting infrastructure).

— The location of existing depots may not be optimal for installing charging and/or refueling infrastructure due to the lack of proximity to power/distribution networks.

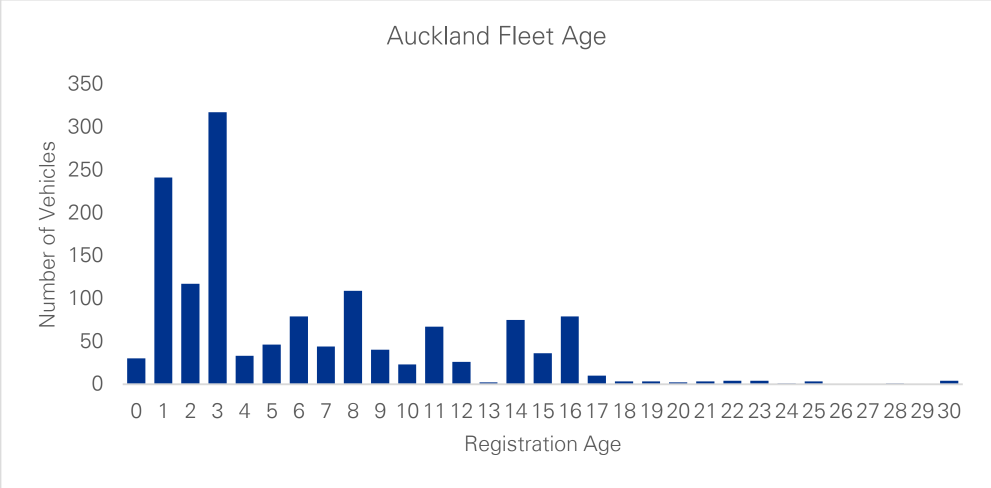
— Competing Strategic objectives by Regional Government and limitations of existing technology e.g. Greater Wellington Regional Council's strategy includes the adoption of higher capacity (double decker) buses on main routes to reduce congestion[1], however existing technology may not support such an initiative (e.g. battery life may not support route etc).

Market Structure

— The fragmented nature of the New Zealand bus market. New Zealand's buses are privately owned, and fleet size and composition vary considerably between operators. Fleets are aligned to requirement for urban buses and regional quality standards which can vary region to region.

— Under PTOM the maximum permitted vehicle age is 20 years. The age of New Zealand's bus fleet is considered relatively new, noting fleet ages vary region to region. Changes in market dynamics may result in significant orphaned assets that are within the permitted 20 year age range but can not be used for PTOM Units due to new specifications.

— The table adjacent illustrates the registration age of the Auckland bus fleet which represent greater than 50% of the total urban bus fleet in new Zealand.



Source: KPMG PTOM evaluation

— The lack of a mature secondary market for Zero Carbon Technology in New Zealand.

— There is a high correlation of ownership for fleets, depots and infrastructure with limited incentive for organic transition to Zero Carbon Technology under the current framework.

— Operators are reluctant to implement wide scale adoption of untested technology due to associated risks.

Contractual Landscape

— Regional Councils' application of PTOM can vary region to region, creating uncertainty for operators which are considering investing in new technologies, e.g. Central Government is responsible for setting the policy objectives for land transport with Regional Councils (and AT) responsible for the delivery.

— The existing PTOM framework requires operators to bring their own fleet and depots, with few instances where Zero Carbon Technology is a set requirement / specification at the time of procurement. This is gradually changing with regions seeking to increase procurement of Zero Carbon Technology through updated specifications.

1. Greater Wellington Bus Services Request for Tender (PTOMBUS-1491931408-8)

Background

Barriers to widespread adoption cont.

- Asset risk sits largely with operator who have limited historical performance data of new technologies.
- Whilst many existing PTOM contracts would permit the transition to electric buses within existing terms, contract variations (specifically around subsidies), would likely be required due to the high upfront capital costs associated with Zero Carbon Technology buses.

Timing

- The lead times to procure, test and implement Zero Carbon Technology vary significantly depending on location, existing infrastructure portfolio and technology adopted.

Flexibility

- Zero Carbon Technology buses may offer less flexibility than diesel buses, due to their range and reliance on different charging/fuelling requirements.
- The lack of long-term experience with running Zero Carbon Technology buses on a commercial scale may also create uncertainty.

Operators Financial Position

- Transition to Zero Carbon Technology fleets will require a significant capital investment. Operators many not have the ability to raise funds required to meet this requirement.

B

Technology

Potential zero carbon technology options that New Zealand could deploy

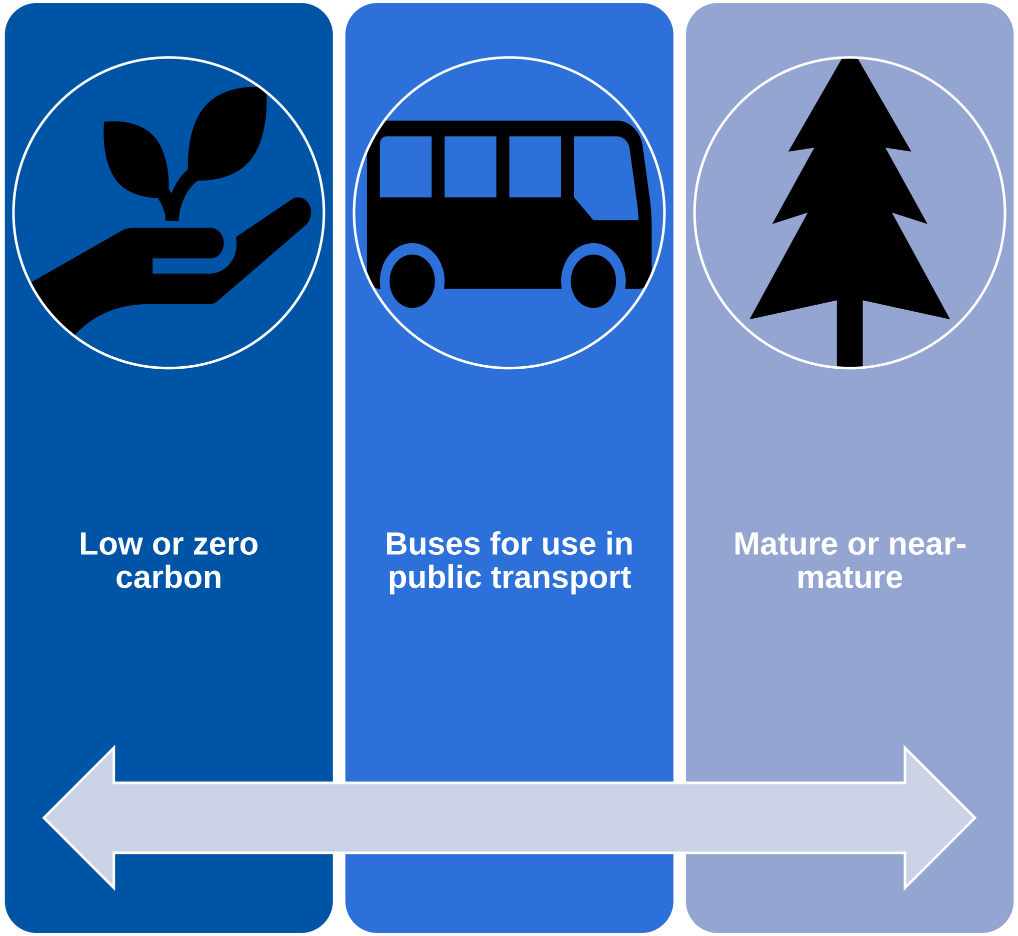
Scope

The scope for technology refers to options for low or zero carbon emitting buses for use in urban public transport, using mature or near-mature technologies. Examining the specific meanings of those terms:

Low or zero carbon – technologies for vehicle propulsion with potential for significantly lower (below 50%) operating (net over the fuel's lifecycle) greenhouse gas (GHG) emissions than existing engines using petrodiesel. This can include technologies with relatively high GHG emissions (or other environmental impacts) associated with vehicle, vehicle component and supporting infrastructure construction (e.g. in battery production).

Buses for use in urban public transport – road vehicles providing 12 or more seating positions and with a self-contained energy storage and traction power systems. Providing services between locations predominantly within a single urban area for the general public, usually operated under contract to the regional council/Auckland Transport or classified as an exempt service under PTOM.

Mature or near-mature – technologies for bus propulsion currently deployed in significant numbers in several urban bus fleets globally. This includes technologies being trialled in-service on complete routes in multiple cities, but excludes technologies that are at the prototype stage or being tested in-service only using demonstrator vehicles.



Technology

Long List

Technology	Summary	Low or zero carbon	Buses for use in public transport	Mature or near-mature
Battery-electric	Fully electric propulsion; electric motor powered by on-board batteries and/or supercapacitors.	✓	✓	✓
Hydrogen fuel cell	Fully electric propulsion; electric motor powered by on-board hydrogen fuel cell.	✓	✓	✓
Biomethane	Internal combustion engine powered by methane produced from renewable sources.	✓	✓	✓
Diesel (synthetic)	Internal combustion engine powered by diesel produced from renewable sources.	✓	✓	✓
Diesel (fossil)	Internal combustion engine powered by diesel produced from non-renewable sources. Baseline for assessing net carbon emissions from buses - not near-zero.	✗	✓	✓
Biodiesel	Internal combustion engine powered by diesel produced from non-renewable sources, blended with fatty acid methyl ester produced from renewable sources. Net carbon emissions around 20% lower than fossil diesel but not near-zero.	✗	✓	✓
Natural gas	Internal combustion engine powered by methane produced from non-renewable sources. Net carbon emissions comparable to pure diesel - not near-zero.	✗	✓	✓
Trolley bus	Fully electric propulsion; electric motor powered by external supply from overhead wires. Operation generally constrained by availability of on-street infrastructure for 50%+ of route.	✓	✗	✓
Electric hybrid (standard)	Internal combustion engine powered by diesel, methane or gasoline – usually from non-renewable sources. This is combined with an electric motor powered by on-board batteries and/or supercapacitors, charged during vehicle operations. Net carbon emissions around 15% lower than a pure internal combustion system but not near-zero.	✗	✓	✓
Electric hybrid (plug in)	Internal combustion engine powered by diesel, methane or gasoline – usually from non-renewable sources. This is combined with an electric motor powered by on-board batteries and/or supercapacitors, charged during vehicle operations and by external charging. Net carbon emissions around 30% lower than a pure internal combustion system but not near-zero.	✗	✓	✓

Considered further

Removed during sift

Technology

Long List cont.

Technology	Summary	Low or zero carbon	Buses for use in public transport	Mature or near-mature
Autogas	Internal combustion engine powered by hydrocarbon gases (principally propane and butane) produced from non-renewable sources. Net carbon emissions lower than diesel – but are not near-zero.	✗	✓	✓
Gasoline	Internal combustion engine powered by gasoline produced from non-renewable sources. Engine performance is generally not suited to heavy vehicles such as buses and net carbon emissions are higher than diesel.	✗	✗	✓
Fly wheel hybrid	Internal combustion engine powered by diesel, methane or gasoline – usually from non-renewable sources. This is combined with a large flywheel used for storing energy produced during vehicle operations. This is not a mature or near-mature technology at this stage. Net carbon emissions thought to be lower than a pure internal combustion system but not near-zero.	✗	✓	✗
Liquid nitrogen hybrid	Internal combustion engine powered by diesel, methane or gasoline – usually from non-renewable sources. This is combined with a liquid nitrogen system used to power low-speed propulsion using heat produced during vehicle operations. This is not a mature or near-mature technology at this stage. Net carbon emissions thought to be lower than pure internal combustion system but not near-zero.	✗	✓	✗

Removed during sift

Based on this sift, the following technologies have been considered:

1. Battery-electric;
2. Hydrogen fuel cell;
3. Biomethane; and
4. Synthetic diesel.

Battery Electric Buses

Technology Overview

Fully battery-electric vehicles use electricity to drive an electric motor that provides propulsion. This electricity can be drawn from on-board batteries or super-capacitors. The electrical energy is the sole means of propulsion for the vehicle and primarily originates from external sources.

Fully electric buses largely fall into one of two types:

— Opportunity-charging buses which are equipped with small batteries or super-capacitors and regularly recharge whilst in service using overhead line equipment or using induction charging equipment set into the carriageway; or

— Depot-charging buses which are equipped with medium-to-large battery packs that are recharged via slow charging systems overnight or by fast-charging systems (usually at the depot or terminus point) during breaks in service.

Motor Technology

Electric motors use the interaction of magnetic fields to produce rotational movement. An electrical current is passed through a conducting material coiled around magnetic core, forming a central rotor. This creates a magnetic field around the rotor, which ‘pushes’ against the magnetic field around the outer stator (created by either permanent magnets of electromagnets), causing the rotor to turn. For the rotor to keep turning the current must regularly change direction, either through use of a mechanical or electronic commutator for a DC current or through use of AC current.

Electric motors offer a number of significant advantages over combustion engines:

— Conversion of stored energy into kinetic energy with a high peak level of efficiency - between 70 and 90% (compared with around 45% for diesel engines);

— Ability to operate as a generator, allowing the vehicle to recharge the traction batteries during deceleration in a process referred to as regenerative braking;

— Very smooth torque curve, allowing rapid acceleration from a stopped position and contributing to a smooth ride for passengers; and

— Less noisy than diesel or gas engines.

Vehicle Emissions

Battery-electric buses produce almost no emissions (such as nitrous oxides, carbon monoxide, or particulates) at the point of use (except particulates from brake and tyre wear) and so have only a minimal negative impact on local air quality.

Although no carbon dioxide is directly produced by the traction system of the battery-electric bus, the batteries are charged with electrical energy drawn from an external source – usually the power grid (but potentially from a local power source if the depot has its own supply from a generator, solar panels, wind turbine or similar). This means that the operating emissions footprint of a battery-electric bus is determined by the energy sources used for the production of electrical power for the grid.

The New Zealand power grid is principally (82%) supplied by renewable sources (primarily hydro, geothermal and wind), with the remainder (18%) being supplied by fossil fuel plants (natural gas and coal). This high level of low-carbon power supply result in a low level of carbon dioxide-equivalent (CO_2e) emissions per unit of electrical energy.

Traction battery manufacturing is a relatively carbon-intensive process, so battery electric buses start their operating lifecycle with a material carbon debt compared with a diesel bus, which takes two to four years of operation to pay off. The extra embedded carbon in a battery electric bus varies considerably with the energy sources used for electricity generation at the manufacturing location, but can be up to 50% higher than for a diesel bus.

Energy Requirements

Historically the main limiting factor in the adoption of battery-electric buses has been energy storage. The two main energy storage options for a bus are batteries and super-capacitors:

— Batteries are capable of storing a relatively large amount of electrical energy, but are limited in the rate of input and output of energy that they can achieve for charging and discharging respectively. This results in long charging times, as well as limited acceleration and top speed.

— Super-capacitors can charge and discharge more rapidly than batteries, allowing for greater acceleration and top speed. However, they have a relatively low capacity for electrical energy that limits their use to short distances, requiring regular recharging in-service via induction or overhead lines.

Battery Electric Buses cont.

A key issue with both traction batteries and super-capacitors is the current level of uncertainty regarding the longevity of their efficient service life. There is emerging evidence of heavy vehicle traction battery packs having achieved a service life of at least 7 years, but advances in technology are such that the early examples of traction batteries reaching the end of their life are now obsolete and so do not provide a good guide to the expected service life of the current generation of lithium-ion traction batteries.

Battery Electric Pros and Cons

Pros	Cons
Maturity – battery-electric buses are now operating in significant numbers in global bus fleets, including in cities across Europe and North America and trials are underway in Australia and New Zealand.	**Charging infrastructure** – battery-electric buses will require significant charging infrastructure at the depot, in addition to charging infrastructure on-street if opportunity charging is to be used. This infrastructure will require space and may also require reinforcement of grid transmission infrastructure.
Established NZ energy supply chain – battery-electric buses use electrical power directly, allowing the main electrical grid to be used (subject to generation and transmission capacity).	**End of life risks** – pathways for recycling batteries at their end of life are not well established and understanding of residual values for battery-electric buses is limited. May be potential for batteries to be reused in lower-intensity applications, including in chargers. Progressive reductions in battery costs will reduce financial risks.
Air quality – battery-electric buses are fully zero-emission at the tailpipe, emitting only minimal local air pollutants from brake and tyre wear.	**Constrained operation** – relatively low energy density of batteries mandates trade-offs between range and passenger capacity. Use of opportunity charging may require additional cycle time, with a resulting impact on peak vehicle requirement and fleet size.
GHG emissions – use of grid electricity will result in only low levels of carbon emissions, which can be reduced towards zero as the energy sector moves towards full renewable generation.	

Global Implementation

At the time of writing, battery-electric traction for buses is a newly mature technology. A number of pilot projects have been completed in cities across Europe to test the viability of battery-buses as part of the ZeEUS (Zero Emission Urban bus System) programme, involving up to five vehicles per fleet. Larger-scale roll-out of battery-electric buses is now underway in cities including Toronto, London, Paris, Trondheim and Los Angeles.

World-wide, large fleets of battery-electric buses have been operating in in Shenzhen and other cities in China for a number of years and now make up more than 17% of the total Chinese bus fleet. At present, the vast majority of battery-electric buses globally are operating in Chinese cities.

In local markets, battery-electric buses have been operating at Sydney and Brisbane airports for the last few years and are being introduced on urban routes in New South Wales, Auckland, Wellington, Christchurch and Tauranga.

Considerations for implementation

1. High up-front costs for vehicles, on the order of NZD750,000 for a 12m single-deck vehicle, compared with around NZD420,000 for the equivalent diesel bus.
2. Uncertainty about the residual value of vehicles and secondary market for vehicles and batteries.
3. Significant investment in depots required under all route operation models (more so for depot-charging-only than for depot and opportunity charging), both for chargers (estimated cost around NZD70,000 per 80kW charger), reinforcement of grid transmission (highly variable with scale and site location) and additional depot space required to accommodate overnight charging.
4. Balance needed between standardisation (e.g. charging connectors and electrical supply characteristics for charging) and route specific localisation (e.g. supercapacitor peak power needed for local topography and battery-pack sizing balance between weight and range).
5. Developments in battery technology and cost reductions could advantage delayed investment in this technology.

Case Study

Refer case study 1, 2 and 3

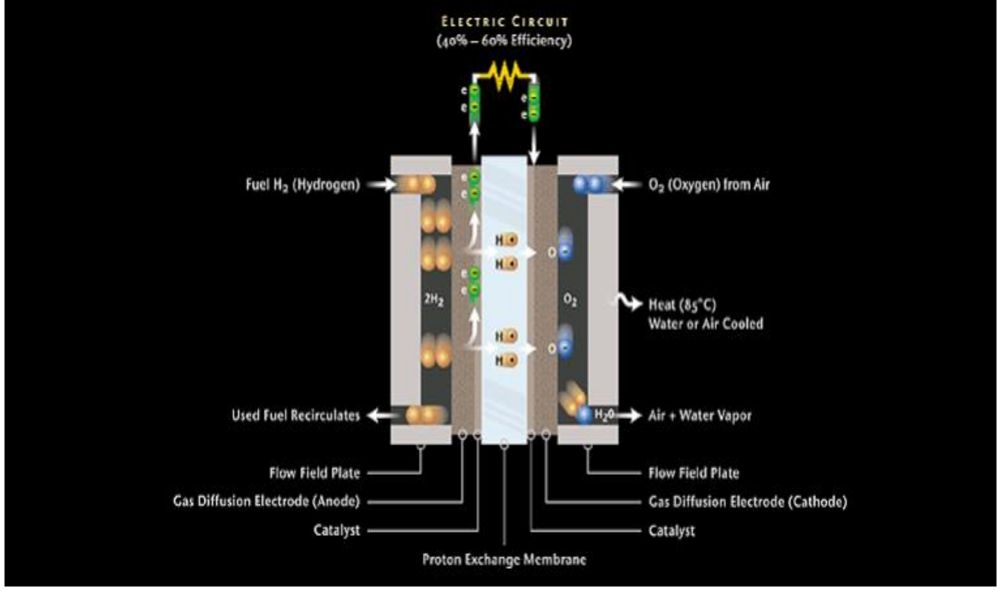
Hydrogen Fuel Cell Bus

Technology Overview

Hydrogen fuel cell vehicles use electricity to drive an electric motor that provides propulsion, in the same process as used in battery-electric vehicles. The key difference is that the electrical energy is primarily provided from a hydrogen fuel cell, supplemented by a small battery for storing energy recovered during regenerative braking.

Motor Technology

A fuel cell is an electrochemical conversion device which generates electricity by a proton-exchange mechanism, using fuel on one side and an oxidant on the other, which react with each other in the presence of an electrolyte. The following provides a visual representation of this process.



Source: Transport For London

Fuel cells can operate virtually continuously as long as the necessary flows are maintained.

Many combinations of fuel and oxidant are possible: e.g. a hydrogen cell uses hydrogen as fuel and oxygen as the oxidant.

Vehicle Emissions

Fuel cell vehicle technology provides an alternative to all-electric drivetrains for urban bus operations without pollutant exhaust emissions. The main emission produced by a hydrogen fuel cell bus at the point of use is water vapour.

There is currently only very limited hydrogen production carried out in New Zealand; a future roadmap for production is set out in the 2019 Green Paper, '*A Vision for Hydrogen in New Zealand*'. This identifies four different types of hydrogen by means of production:

- **Green hydrogen** - produced using renewable electricity to power an electrolyser, splitting water molecules into the constituent elements of hydrogen and oxygen;
- **Brown hydrogen** - produced using non-renewables either to generate electricity to power an electrolyser, or through steam methane reforming;
- **Blue hydrogen** – produced using the same base processes as brown hydrogen with carbon capture or offset used to cut the associated GHG emissions; and
- **Grey hydrogen** – produced during industrial processes.

Green and blue hydrogen have relatively low CO_2e emissions per unit of hydrogen, compared with brown and grey hydrogen. The Green Paper identifies green hydrogen as the focus for the hydrogen roadmap, supported by the high proportion of New Zealand's electrical power generated from renewable sources (refer above).

Energy conversion for storage and use via green hydrogen is currently less efficient than batteries, resulting in a lower net conversion from renewable electrical energy source to energy for propulsion. However, hydrogen is more energy-dense than batteries so hydrogen fuel cell buses are typically lighter than equivalent battery electric buses, requiring less energy for propulsion. At the time of writing, no direct comparison is yet available to assess which technology will produce the lowest CO_2e emissions per km.

Hydrogen Fuel Cell Bus cont.

Hydrogen Fuel Cell Pros and Cons

Pros	Cons
Flexible operation – hydrogen fuel cell buses can have a similar range to diesel buses (around 300-450km) and a similar refuelling time (less than 10 minutes) as well. This will allow fuel cell buses to directly replace diesel buses on most routes.	**Technology still maturing** – hydrogen fuel cell buses are nearing maturity and are currently being deployed in-service in pilot projects around the world, but have not yet progressed to full maturity and mass roll-out. Availability of buses from manufacturers is still limited and costs are very high.
Limited infrastructure requirement – if hydrogen is produced offsite, the vehicle operating range enables overnight refuelling at depots using infrastructure with a similar footprint and electrical power requirements to diesel storage and refuelling equipment.	**Limited New Zealand supply chain** – meeting the hydrogen requirements for deployment of fuel cell buses in significant numbers will require the existing production of hydrogen in New Zealand to be increased many times over, as will the provision of transport, storage and refuelling assets.
Air quality – fuel cell buses are fully zero-emission at the tailpipe, emitting only minimal local air pollutants from brake and tyre wear.	**End of life risks** – understanding of residual values for hydrogen fuel cell buses is very limited.
GHG emissions – use of green and/or blue hydrogen will result in only low levels of carbon emissions, which can be reduced towards zero as technology and the energy sector develops.	**High fuel costs** – fuel cost expected to be significantly higher than for fossil diesel.

Global Implementation

Hydrogen fuel cell technology is currently being piloted in service on urban bus routes around the globe. Notable projects include those completed and underway in cities across Europe to test the viability of fuel cell buses as part of the CHIC (Clean Hydrogen in European Cities), High V.LO-City, HyTransit, 3Emotion (Environmentally-friendly Efficient Electric Motion) and MEHRLIN (Models for Economic Hydrogen Refuelling Infrastructure) programmes, involving up to ten vehicles per fleet.

Larger-scale roll-out of hydrogen fuel cell buses is now underway as part of the JIVE/JIVE2 (Joint Initiative for hydrogen Vehicles across Europe) and H2Bus programmes in cities including Aberdeen (UK), London (UK), Cologne (Germany), Bolzano (Italy), Akerhus (Norway) and Groningen (Netherlands).

The first hydrogen fuel cell bus trial in New Zealand is planned to start in Auckland during September 2020.

Considerations for Implementation

1. High up-front costs for vehicles, on the order of NZD1,000,000 for a 12m single-deck vehicle, compared with around NZD420,000 for the equivalent diesel bus.
2. Uncertainty about the residual value of vehicles and the associated secondary market.
3. Investment in depots required to provide hydrogen storage and refuelling, this could potentially require more space during transition between diesel and hydrogen fuel cell vehicles.
4. Need to align implementation with development of the hydrogen economy in New Zealand.

Case Study

Refer case study 4

Biomethane Bus

Technology Overview

Fossil natural gas is formed from buried organic material, and has methane as the dominant component. Natural gas for use as a transport fuel is normally either:

— compressed at high pressure (200 to 250 Bar) with on-vehicle storage in tanks either under the floor or on the roof of buses as Compressed Natural Gas (CNG); or

— condensed in a liquid form at a temperature of around -163℃ at a pressure of between 1 and 8 bar and is stored in tanks at the rear of the bus as Liquefied Natural Gas (LNG).

Natural gas can also be produced by anaerobic digestion of organic material including agricultural, animal and food waste, sewage sludge, energy crops or wastewater. This is biogas or, in upgraded form with carbon dioxide and other contaminants removed to make it suitable for use as a transport fuel, biomethane. Biogas can also be produced through thermo-chemical processes (SNG production) using woody feed stocks, but these processes are not yet in widespread use globally.

Biomethane is thus a renewable transport fuel which, dependent on the production pathway, is considered to be close to carbon neutral (around 80% lower than diesel). When used in vehicles it has very low exhaust emissions, thus contributing to improved local air quality compared with pre-Euro VI diesel buses. Gas powered vehicles are also considerably quieter than conventional diesel vehicles.

Engine Technology

Dedicated methane gas engines are spark ignition (SI) engines optimised to run on 100% methane. These engines display significantly lower combustion noise than their diesel equivalents, but are also less energy efficient than diesel engines employing compression ignition technology.

Gas engines can be paired with an electric motor and batteries in a hybrid system, combining some of the characteristics of a biomethane and a battery electric bus. This allows for the use of electrical energy to contribute to propulsion, resulting in reduced biomethane usage and tailpipe emissions. This comes at the expense of additional costs for purchase and maintenance (due to higher system complexity and limited battery lifespans) and increased vehicle weight (potentially constraining capacity and/or road wear).

Vehicle Emissions

Emissions data enabling a direct comparison to be made between Euro VI CNG buses and diesel vehicles of the same Euro standard is not readily available and the historic data we have found shows some large variations in air quality emissions performance for heavy CNG vehicles relative to a Euro VI diesel vehicle. However, the general picture is that emissions of both oxides of nitrogen (NOx) and particulates (PM) are typically significantly lower for gas buses than for pre-Euro VI diesel vehicles.

Fuelling Requirements

There are no specific fuel quality standards for natural gas or bio methane analogous to those that exist for gasoline and diesel fuel. However, gas standards do exist for vehicle emissions testing to Euro standards and there is a Swedish standard for biogas produced by anaerobic digestion for use as a transport fuel. Biogas produced to this standard is able to be used in engines designed for natural gas without modification.

CNG

There are two basic methods of fuelling CNG vehicles: slow fill and fast fill. Slow fill systems take gas directly from the compressor into the vehicle. The refuelling time for a large vehicle can be in excess of three hours, but slow fill systems may be suitable for bus operations where vehicles can be refuelled overnight. Fast fill systems typically use compressors and cascade fuel storage tanks (other systems are available) and can refuel vehicles in times similar to diesel powered vehicles.

LNG

LNG can be delivered to bus depots by tanker, as is done with diesel fuel, and then stored in cryogenic tanks. Vehicle fuelling takes place via dispensers, taking about three minutes for a complete fill.

Biomethane Bus cont.

Biomethane Pros and Cons

Pros	Cons
Flexible operation – biomethane buses can have a similar range to diesel buses and a similar refuelling time	**Air quality** – biomethane buses are low (but not zero) emission at the tailpipe, emitting low levels of local air pollutants.
Limited infrastructure requirement – the vehicle operating range enables overnight refuelling at depots using infrastructure with a similar footprint and electrical power requirements to diesel storage and refuelling equipment.	**GHG emissions** – biomethane is a low carbon fuel, but no pathway to fully zero carbon has been developed at this time.
Established NZ energy supply chain – biomethane supply chains are already established in New Zealand and can potentially be expanded to meet demand from a biomethane bus fleet.	**High fuel costs** – fuel cost expected to be significantly higher than for fossil diesel.
Fully mature technology – biomethane buses are a fully mature technology are currently in use on service routes in cities around the world, including in cities across Europe. Natural gas buses (including fossil gas) were formerly in widespread use in New Zealand and are currently in operation in many cities globally, including across Australia, Europe and North America.	

Global Implementation

Natural gas buses are in widespread operation globally. Biomethane is used as fuel at many locations, including Nottingham, Norfolk/Suffolk, Bristol and Reading in the UK, as well as in Vancouver (Canada), Lille (France), Helsinki (Finland) and Skåne (Sweden).

Considerations for implementation

1. Investment in depots required to provide biomethane storage and refuelling, this could potentially require more space during transition between diesel and biomethane vehicles.
2. Need to align implementation with growth of the biomethane industry in New Zealand, although fossil gas could meet shortfall in the interim.
3. This is a low, but not zero emission technology with no clear pathway apparent for reaching zero emissions of GHG and local pollutants. This would not be the optimal solution for sustainability.
4. Additional weight of on-vehicle LNG or CNG storage may constrain passenger capacity and affect required service provision..

Case Study

Refer case study 4

Synthetic Diesel Bus

Technology Overview

Fossil diesel fuel is a complicated mix of hydrocarbons, usually refined from crude oil through fractional distillation. When used as a transport fuel, diesel is usually stored in tanks low down in the body of the vehicle.

Synthetic diesel is chemically very similar to diesel from fossil sources and be substituted directly for fossil diesel. The production process for synthetic diesel is currently based upon the reaction of fats and waste oils with hydrogen, but these fats and waste oils have a high cost and supplies are limited. A number of different processes for producing synthetic diesel from cheaper raw materials – particularly cellulose-based biomass – are currently being researched. However, these processes and technologies are not commercially proven for large-scale production.

Synthetic diesel is distinct from biodiesel, which is a fatty acid methyl ester (FAME), produced by reacting fats and oils with methanol. Biodiesel has significant chemical differences from fossil diesel and can only be used in unmodified engines when blended with fossil diesel (typically up to 7% biodiesel), limiting its suitability as a low or zero carbon fuel.

Engine Technology

A diesel engine uses the high temperature created when a gas is greatly compressed in order to ignite the fuel. This contrasts with spark-ignition internal combustion engines, in which ignition of the fuel is initiated by the use of spark plugs. Diesel engines can also be referred to as compression-ignition engines.

Diesel engines have a higher thermal efficiency than any other standard internal combustion engine, resulting from their very high compression ratios and heat dissipation by excess air which results from the lean burn of these engines. Worldwide, diesel engines have for some years been the primary means of bus propulsion due to the greater torque, reliability and safety offered compared with petrol and the lower fuel costs and maturity of the technology when compared with most alternatives.

Diesel engines can be paired with an electric motor and batteries in a hybrid system, combining some of the characteristics of a diesel and a battery electric bus. This allows for the use of electrical energy to contribute to propulsion, resulting in reduced diesel usage and tailpipe emissions. This comes at the expense of additional costs for purchase and maintenance (due to higher system complexity and limited battery lifespans) and increased vehicle weight (potentially constraining capacity and/or road wear).

Vehicle Emissions

New Zealand standards for heavy duty vehicle emissions generally follow Euro standards. These have been set in a series of EU directives; these regulate the emission levels of carbon monoxide (CO), hydrocarbons (HC), nitrous oxides (NOx) and particulate matter (PM).

The table below illustrates the progressive reduction in emissions achieved up until the latest Euro VI standard.

Standard	Date of European Implementation	Maximum Emissions(g/kWh) based on Stationary Cycle			
		CO	HC	NO_x	PM
Euro I	1992, ≤85kWh	4.500	1.100	8.000	0.612
	1992, >85kWh	4.500	1.100	8.000	0.360
Euro II	October 1996	4.000	1.100	7.000	0.250
	October 1998	4.000	1.100	7.000	0.150
Euro III	October 2000	2.100	0.660	5.000	0.100
Euro IV	October 2005	1.500	0.460	3.500	0.020
Euro V	October 2008	1.500	0.460	2.000	0.020
Euro VI	January 2014	1.500	0.130	0.400	0.010

Source: Mott MacDonald

In general, greenhouse gas emissions are not controlled by Euro standards and are primarily driven by vehicle fuel economy.

Synthetic Diesel Bus cont.

Synthetic Diesel Pros and Cons

Pros	Cons
Flexible operation – diesel buses set the baseline for bus range.	**Air quality** – a modern Euro VI diesel bus is low (but not zero) emission at the tailpipe, emitting low levels of local air pollutants.
No infrastructure requirement – synthetic diesel can be used in existing refuelling infrastructure..	**GHG emissions** – synthetic diesel is a (net) low carbon fuel (80-90% lower than diesel), but no pathway to fully zero carbon has been developed at this time.
Fully mature technology – diesel buses are a fully mature technology used in a significant majority of buses and heavy vehicles in New Zealand and worldwide.	**Limited NZ energy supply chain** – supply chains for producing synthetic diesel are limited in New Zealand and expansion to meet demand from a synthetic diesel bus fleet would be dependent upon currently immature technologies.
	High fuel costs – fuel cost expected to be significantly higher than for fossil diesel.

Global Implementation

Diesel remains the default option for bus propulsion in most global cities, except where historic policies have resulted in fleets of gas buses or electrical trolleybuses. The emergence of more sustainable technologies in mature forms is starting to challenge the dominance of diesel – as a fossil fuel at least.

The use of synthetic diesel is less widespread; this fuel is currently being used in Sweden (Stockholm) and in the USA (Portland, Santa Barbara, as well as in other municipal heavy vehicle fleets across California).

Considerations for implementation

1. Need to align implementation with growth of the synthetic diesel industry in New Zealand, although fossil diesel could meet shortfall in the interim.
2. This is a low, but not zero emission technology with no clear pathway apparent for reaching zero emissions of GHG and local pollutants. This would not be the optimal solution for sustainability, but could form part of a multi-technology transition towards zero emission.

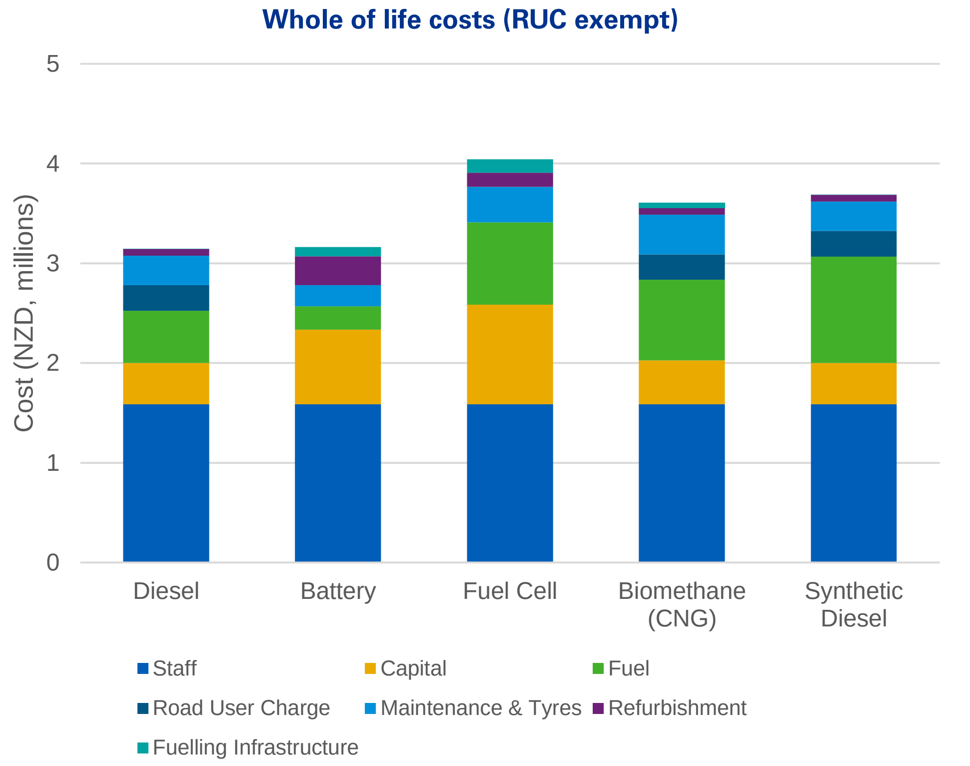
Whole of life costing

Considering the whole-life costs of the vehicles, assuming that each bus is used for 20 years before becoming life-expired and assuming that each bus covers 80,000km per year allows an indicative estimate to be made of the total cost of owning a typical vehicle of each type. The cost presented in this report are indicative only and should be further tested through a business case specific to implementation plan e.g. consider the specific depot sites.

The cost elements included and excluded are summarised as follows:

Cost Element	Included	Comment
Vehicle capital cost	Yes	Full purchase and delivery.
Vehicle maintenance	Yes	Staff and materials (and tyres).
Driver	Yes	Includes benefits, supervision and management.
Refurbishment	Yes	Drive system and interior.
Battery replacement	Yes	Based on current battery prices.
Fuel	Yes	Based on assumed 80,000km per annum.
Road User Charge	Yes	Based on current charges and exemptions.
Refuelling infrastructure	Yes	Full installation and upgrades.
Vehicle insurance	No	Insufficient information, assumed consistent across technologies.
Additional training	No	Assumed non-material over 20-year lifespan.
Other overheads	No	Base depot and back-office costs - assumed consistent across technologies.
Additional depot space	No	Highly site-specific.
Residual value	No	High level of uncertainty.

The indicative whole-life costs for a 12m single-deck bus over 20 years at a 6% discount rates is presented (to the right) for each technology . This estimate is based on Road User Charge (RUC) exemption for heavy electric vehicles (assumed to cover both battery-electric and hydrogen fuel cell) being extended beyond the current deadline of 2025.



Source: Mott MacDonald

The indicative discounted costs of a diesel and a battery-electric bus are expected to be broadly similar, at NZD3.1 – NZD3.2m; the additional purchase and battery replacement costs for the battery-electric bus are counterbalanced by the savings on energy and road user charge. A range of estimates for electrical grid upgrades to support depot charging have been found, from $8.5k to $160k per bus, depending on the site. An average has been used for the purpose of calculating whole of life costs which means at some depots the battery-electric bus option will be more costly.

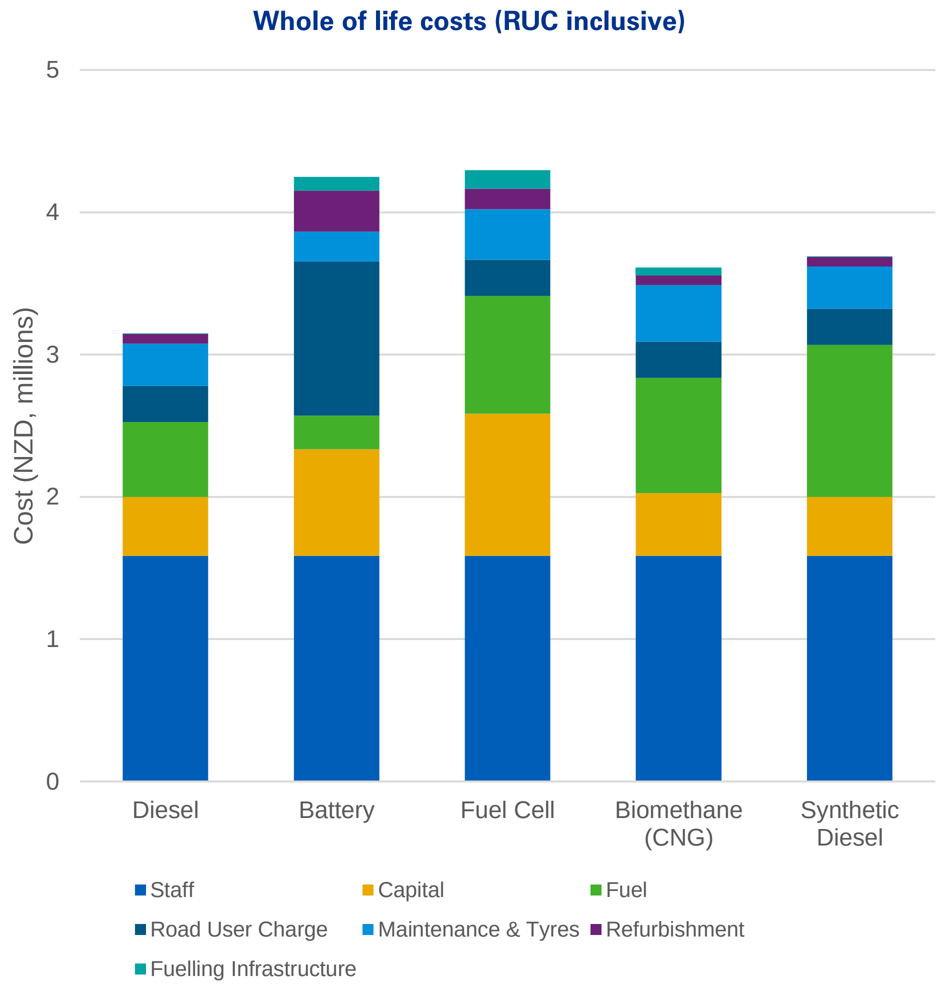
As battery costs continue to reduce and battery lifespans increase over the next 10 years, this parity is expected to end as battery-electric becomes the lower cost option.

Whole of life costing cont.

A fuel cell bus is predicted to have an indicative discounted cost of around NZD4.0 – NZD4.1m; this is significantly higher than for the more mature technologies. The additional cost is driven by both the high vehicle purchase cost and the cost of hydrogen fuel. As the technology matures, the capital required for the vehicles is expected to fall, but this is unlikely to achieve competitiveness with diesel unless a lower cost for hydrogen can also be achieved.

The estimated whole-life cost for a biomethane cost is approximately NZD3.6m, cheaper than for a fuel cell but materially higher than for diesel or battery-electric. The cost of biomethane and liability for road user charges are key factors.

In the event that the Road User Charge exemption for heavy electric vehicles is not extended beyond the current deadline of 2025, then both battery electric and fuel cell buses would become liable. The increased weight of large batteries and limited availability of three-axle electric buses in global markets could increase the number of buses paying at the higher rates of RUC (requiring a permit). The resulting comparison of whole life costs is shown to the right.



Source: Mott MacDonald

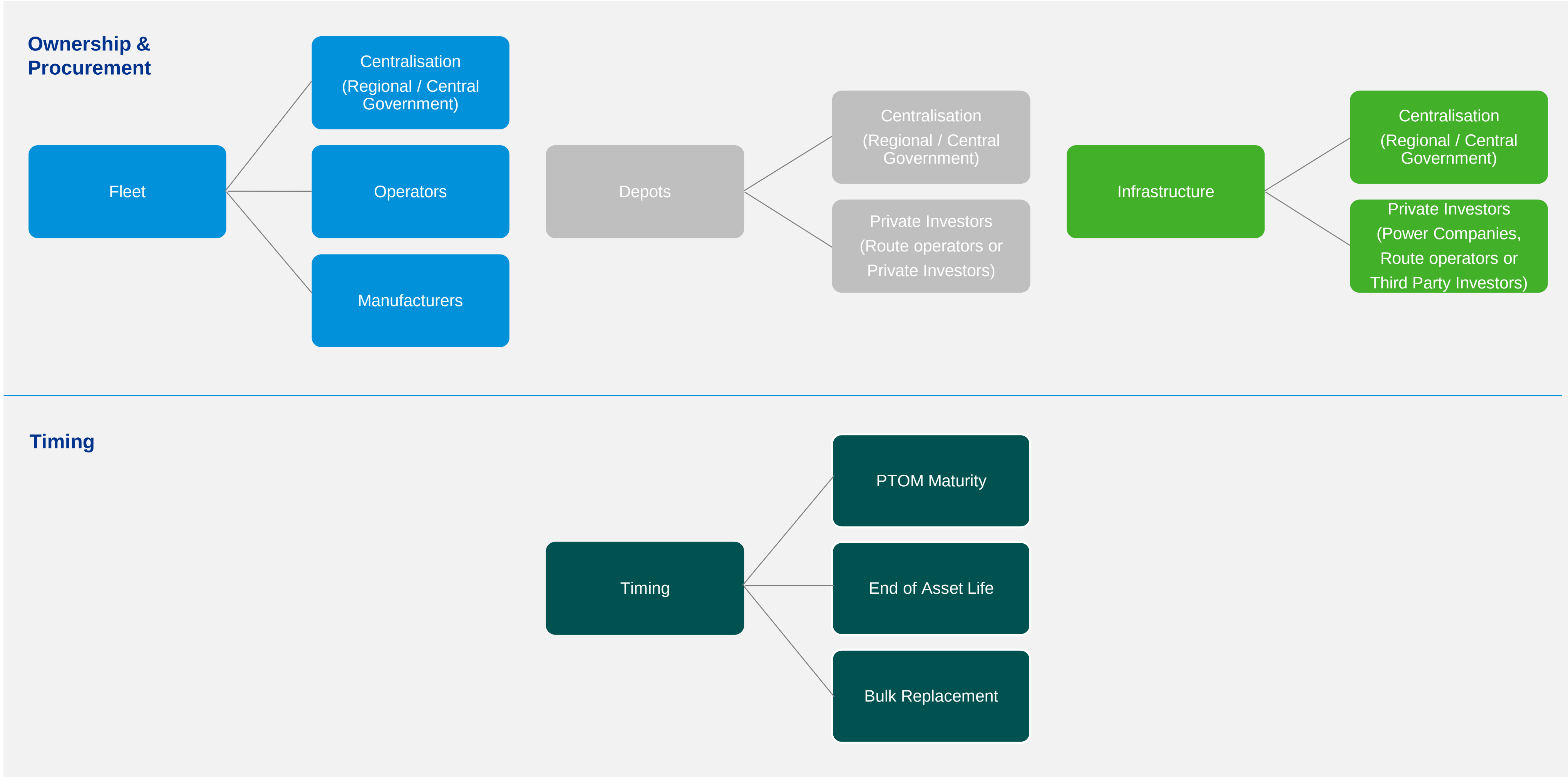
C

Option Development

Option Development

Introduction

We have identified a number of options that would enable New Zealand buses to transition to a zero carbon fleet within twenty years. The options, categorised across Ownership & Procurement and Timing are outlined below. The following slides provide further detail for each option, with the final solution likely comprising a combination of these.

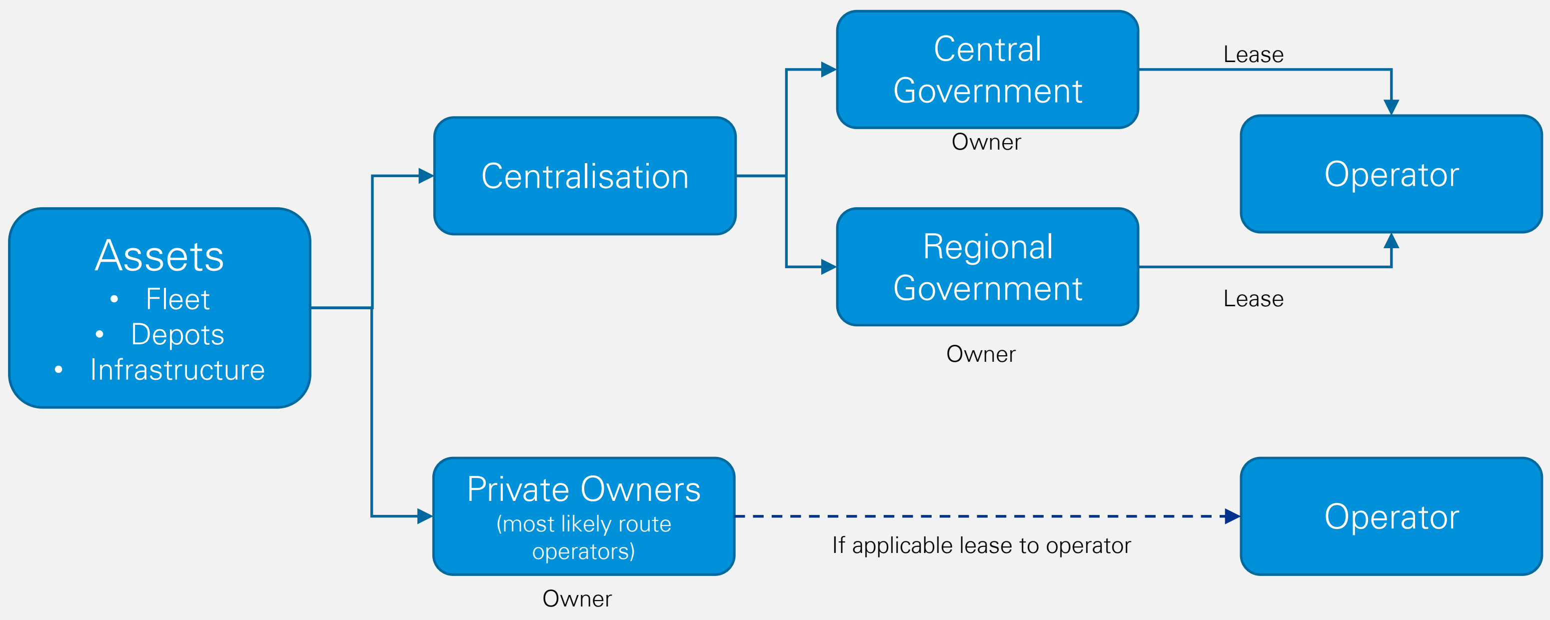


Ownership & Procurement: Scope

Currently in New Zealand, bus fleets, depots and associated infrastructure are procured and owned by the bus operators (predominantly the private sector) with specification for the fleet set by NZTA and the relevant Regional Council or AT.

As previously discussed, various barriers to wide spread adoption of Zero Carbon Technology have been identified. Alternative procurement and ownership models used in other jurisdictions may be applied to New Zealand to assist with overcoming some of theses barriers resulting in an accelerated transition to Zero Carbon Technology. The assessment below explores the potential implications of these options in the New Zealand context. We recommend that all of these implications are tested and further explored with operators and Regional Councils.

The diagram below sets out the general procurement and ownership options this report considers.



Option Development

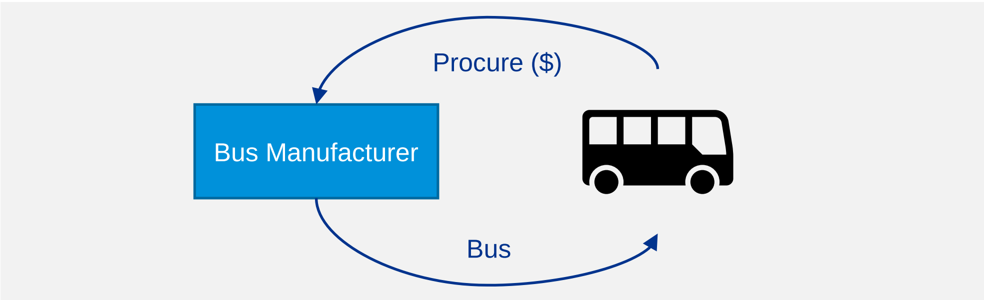
Ownership & Procurement - Fleet - Operators

Overview

The operator ownership structure reflects the status quo in New Zealand with operators responsible for the procurement and ownership of bus fleets.

Key Characteristics

- The responsibility to procure and own the vehicle fleet sits with the operators.
- Operators are required to fund and finance the bus fleet and are responsible for any ongoing obligations in relation to that funding and financing.
- As the asset owner, operators would benefit from proprietary rights in the vehicles which would enable the assets to be pledged as security. This will improve the terms in which the operator would be able to raise finance.
- All asset owning risk (e.g. utilisation, technology, residual asset value, maintenance) would sit with operators as the asset owner(s).



Pros

- Operators currently have expertise in procuring bus fleets and hold the relationship with manufacturers. Many operators have begun piloting battery electric buses, with systems, processes and experience required to manage battery electric fleets already in place.
- As the operator is responsible for the funding and financing of the fleet there would be no upfront capital requirement from Central / Regional Government.
- Ownership by operators provides incentive to innovate and adopt efficient technologies to reduce operating costs. In the long term this may result in savings for the Government with operators able to bid on Units under PTOM with a lower subsidy requirement.
- Operator ownership provides greater flexibility for operators to select technology that complements its route characteristics and operating model (noting overall specification will continue to be set by Central and Regional Governments).
- As operators will own the fleet there is an increased incentive to preserve value in the asset to maximise residual asset value.

Cons

- Purchasing in smaller bundles will unlikely achieve the same bulk purchasing discounts that may be achieved if the procurement function was centralised. Potential bulk procurement discount vs technology "lock in" will need to be considered.
- Transition to Zero Carbon Technology buses could take longer as operators will look to align the transition with the existing fleet's asset life and/ or maturity of existing PTOM contracts (unless PTOM requirements change).
- There is limited secondary market for Zero Carbon Technology buses. Private owners will look to amortise the asset over the life of PTOM contract (6 or 9 years and in very limited circumstances 12 years) or would seek some form of buy back guarantee if contracts do not get extended.
- Enabling buses to be procured by individual operators may result in adoption of various technology types which could create supporting infrastructure interface issues.

Key Considerations

- Several existing operators have already procured battery-electric buses and implemented them into their fleet. As a result, operators internal experience and intellectual property has already been developed. Leveraging this knowledge may improve efficiencies and achieve better value for money for the Government.
- Electric vehicles in particular have limited secondary purpose. Residual asset risk is a factor that has prevented widespread adoption to date. Solutions to de-risk, such as buy back guarantees and/or extended PTOM contracts may encourage further adoption by operators and would enable the cost of capital to be spread over a longer period of time.
- Procurement risk would continue to sit with the operator, with many components of Zero Carbon Technology buses sitting with offshore supply chains. Certainty over future Unit allocations would assist operators in managing timelines and other associated risks dealing with international supply chains (e.g. foreign currency exposure).

Case Study

Refer case study 2 and 5.

Option Development

Ownership & Procurement - Fleet - Centralisation

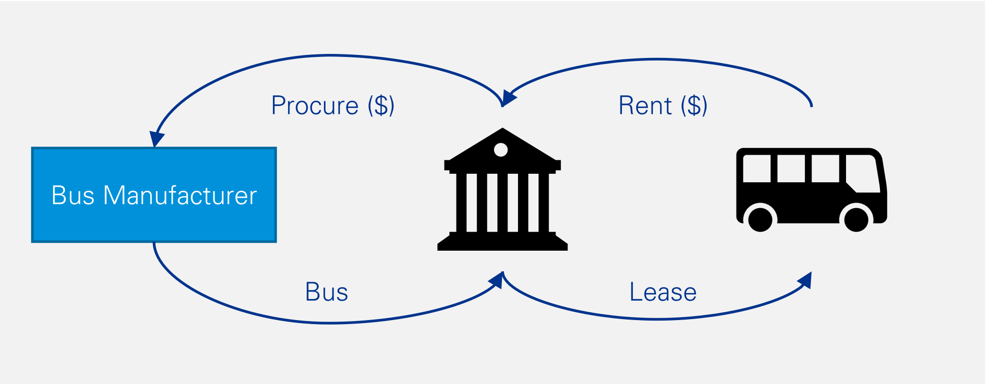
Overview

Under a centralised ownership structure, ownership and procurement responsibilities would fall to either Central Government or Regional Government (i.e. regional councils, local councils and in Auckland, Auckland Transport).

Assets would be leased to various operators and Unit holders.

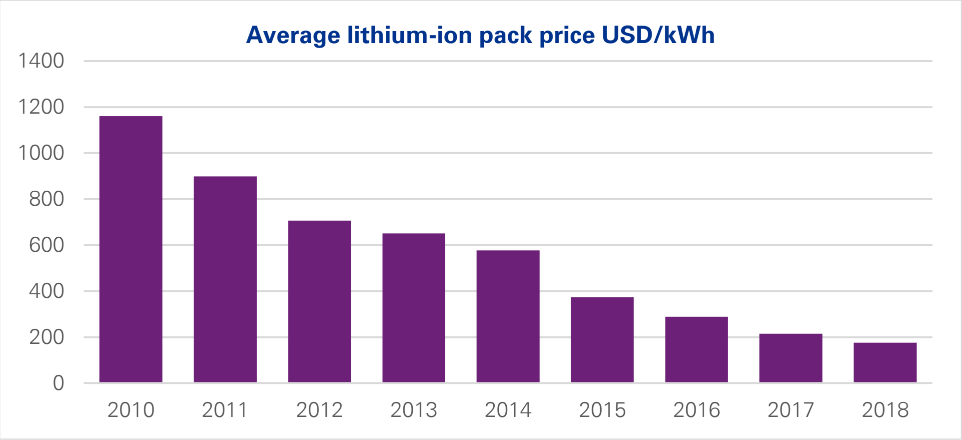
Key Characteristics

- Vehicle fleets would be procured (directly or through agent) and owned by Central or Regional Government.
- Assets would be leased to operators who would pay a regular rental payment in return for access and use of the asset(s).
- At the end of the lease term, the asset(s) would be returned to the asset owner (Central / Regional Government) in a pre-agreed condition.
- As asset owner, the Central / Regional Government would benefit from proprietary rights in the vehicles which would enable the assets to be pledged as security. This may improve the terms in which the Central or Regional Government would be able to raise finance.
- All asset owning risk (e.g. utilisation, technology, residual asset value, maintenance) would sit with the Central / Regional Government as the asset owner(s).



Pros

- Central ownership provides greater control for the Central / Regional Government and can mean more flexibility to deploy assets between regions and operators. Assets can be redistributed throughout the country to meet any changing demand or requirements.
- Whilst Central Government is responsible for setting the policy objectives for public transport, implementation and delivery sits with Regional Councils and the approach to implementation can vary from region to region. To date, individual operators have undertaken the role of adopting new technologies and selecting those that best suit their individual circumstances. A centralised ownership model would enable fleet technology to be standardised across New Zealand, with a single procuring entity indirectly minimising interoperability risk with supporting infrastructure (e.g. charging). Use of a single technology would need to be considered against the suitability foe each region and route e.g. some have longer distances and more hills.
- New Zealand's existing public transport bus fleet is in excess of 2,500 vehicles. Centralising procurement to a single entity strengthens the ability to negotiate bulk procuring discounts.
- Technology costs, specifically those related to lithium ion batteries, have reduced over time. Centralisation of fleet ownership could enable Central / Regional Government to capture the full benefit of these costs saving (compared to Operator-owned fleets where there cost saving sis more likely shared with the Operator).



Source: Bloomberg NEF

Ownership & Procurement - Fleet - Centralisation cont.

Cons:

- New Zealand expertise in bus procurement largely sits with operators. Centralisation would require the establishment of new functions to manage, maintain (unless contracted to operators) and undertake ongoing procurement requirements. Establishment of these functions would result in increased costs for the Government and would need to be implemented over time. Further consideration regarding appropriate structure, management and resource required to successfully undertake this function is required.
- There will be a significant upfront cost required for procurement of fleet. Full replacement would cost in excess of NZD1.850bn (assuming a fleet size of 2500 and purchase price of NZD750,000 per vehicle) vs. NZD1.036bn for diesel bus (assuming a fleet size of 2500 and purchase price of NZD414,500 per vehicle) . In practice this cost could would likely be spread over a longer period of time and will be influenced by the procurement strategy and timeline adopted. As demonstrated in whole-of-life costing (refer to pages 20 and 21), the whole of life cost for a diesel and battery electric bus is comparable however this assumes 1) RUC exemptions are maintained and 2) a averaged infrastructure upgrade costs per bus. Changes to RUC policy and/or upgrade costs can significantly impact the final whole of life cost for Zero Carbon Technology buses.
- Centralisation will require Central / Regional Government to take on the risks associated with asset ownership (e.g. utilisation, technology, residual asset value) which currently sits with operators. Many of these risks could be mitigated however in some instances would require significant structural reform which may have unintended adverse consequences. For example:
  - Utilisation: To mitigate utilisation risk, bus fleets could be linked to PTOM contracts e.g. operators will no longer be required to provide buses under their operational requirements. This will ultimately reduce elements that operators can compete on and may result in operators looking to other aspects of their business for efficiencies (e.g. wages). This may result in conflicts with other Government strategic objectives and should be carefully considered.
  - Residual asset value: If fleets are not owned by operators there is less incentive to preserve the residual asset value. Contractual arrangements can be entered where assets are returned to the owner in a pre-agreed condition.
  - Maintenance risk: By default maintenance risk will sit with the owner of the asset. Asset maintenance requirements can be contracted to the operator who will return the assets back to the owner in a pre-agreed condition.

Key Considerations

- Centralisation of the fleet ownership and procurement function is a significant change from the current operating environment.
- A centralised ownership structure could facilitate the accelerated adoption of Zero Carbon Technology buses throughout the country however the pros, cons, costs and potential secondary impacts associated with implementing such a structure need to be carefully considered.
- Several existing operators (NZ Bus, Transit, Redbus and Go Bus) have begun procurement and implementation of battery electric buses into service. These entities will want to preserve the value, in terms of physical assets and intellectual property, that they have accumulated over time.
- The Central / Regional Government will need to consider the type of entity that it will use for ownership under a centralised structure and evaluate the applicability, pros, cons and ongoing legal requirements of each entity type. For example (below list is not exhaustive):
  - **Public Finance Act 1989 Schedule 4A companies**: are established when the objectives sought (which could be a mixture of social and commercial objectives) might be best supported by joint ownership. An example is City Rail Link Ltd in which the Crown and Auckland Council each have a 50% shareholding. A Schedule 4A company is subject to the Companies Act 1993 and relevant provision of the Crown Entities Act 2004;
  - **Crown entity companies**: Crown entity companies are established and owned by the Crown to further certain policy objectives. Crown entity companies are registered as companies and are subject to the Companies Act 1993 and relevant provision of the Crown Entities Act 2004. Examples of Crown entity companies: Radio New Zealand Limited, Television New Zealand Limited;
  - **State owned enterprises**: State-owned enterprises (SOEs) are Crown-owned companies that are expected to be as profitable and efficient as comparable businesses not owned by the Crown. SOEs are subject to the State-Owned Enterprise Act 1986 and the Companies Act 1993. Examples of SOEs: Transpower New Zealand Limited.

Case Study

Refer case study 1,3 and 4

Option Development

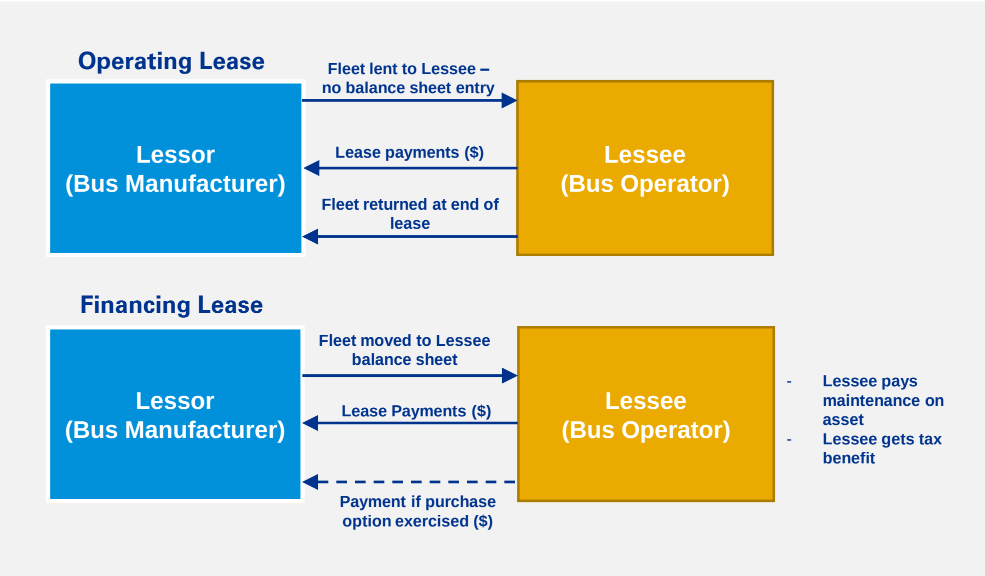
Ownership & Procurement - Fleet - Manufacturers

Overview

Under a manufacturer fleet ownership structure, manufacturers would retain the ownership of the fleet and lease the buses to the respective operators.

Key Characteristics

- Ownership of the fleet would be retained by the manufacturer.
- Assets would be leased (via operating or financing lease) to operators who would pay a regular rental payment in return for access and use of asset(s).
  - Refer funding and financing for key aspects of operating and finance leases.
- All asset owning risk (e.g. utilisation, technology, residual asset value) would be assumed by the manufacturer.
- Maintenance risk may be contracted out to lessee (i.e. operator).



Pros

- Leasing arrangements provide bus operators with increased flexibility and can be an effective mechanism to mitigate exposure to changes in technologies. Where an operator purchases a bus directly itself it is effectively locked into a particular technology for the life of the bus. Lease terms can be shorter than the life of the asset which would enable the lessee to transition to new technology on a more regular basis.
- Maintenance cost are likely to be lower over time as leased buses will typically be newer. Maintenance and parts replacement are likely be covered under manufacturer's warranty.
- Lease terms can be tailored to align with PTOM contracts. This would give the operator certainty of its fleet but would not commit the operator to a particular bus specification or technology beyond this lease period.
- There are limited/no upfront capital costs for Central / Regional Government or operator when leasing a bus.
- In some instances finance lease structures are considered a low cost financing tool removing the upfront capital requirement from the lessee, noting some finance leases include a purchase option at the end of the lease.
- Under an operating lease structure all asset risk remains with the manufacturer (unless contracted out).
- End of asset life risk removed under both operating and financing lease structure as assets are returned to the lessor (i.e. manufacturer) at the end of the lease period. Financing lease structures may include a purchase option at the end of the lease.

Cons

- Whilst operating lease models have been trialled in foreign jurisdictions, including Warsaw (Poland) and New York (USA), there is a limited bus leasing market known in New Zealand.
- As manufacturers control the interface there is a risk that supporting infrastructure may become incompatible and subsequently obsolete with fleet. This risk may be mitigated via amendments to or introduction of standards and/or specifications under PTOM.
- Lease costs may be higher than traditional debt financing and will be influenced by Lessee credit risk profile.

Ownership & Procurement - Fleet - Manufacturers

Key Considerations

- The current ownership framework in New Zealand sees operators owning their respective bus fleets. Implementing a manufacturer ownership model would be difficult to achieve and would likely need to be market driven to be successful.
- Operating lease models have been trialled in foreign jurisdictions however the model is not fully tested in the New Zealand market.
- Further market consultation would be required to establish whether manufacturers have the financial capability and/or risk appetite to adopt this ownership structure.

Case Study

Refer case study 1.

Option Development

Ownership & Procurement - Depot - Private

Overview

Under the current framework, depot ownership is largely held by the private sector, and in many instances by bus operators themselves. This provides operators additional elements to optimise in their PTOM bids. The proximity of depots to routes can have a significant impact on an operator's operating costs by reducing out of service kilometres. Location of depots may become increasingly important with the adoption of Zero Carbon Technology as some new technology may have limitations when compared to diesel incumbents (e.g. battery electric buses have limited range and will need to be able to complete full routes on single charge or have access to on-route charging).

The following structure is a continuation of the status quo with procurement of the property remaining the responsibility of the private investor.

Under this structure investors have the flexibility to procure the depots in the most cost effective manner and will either lease the depots to the bus operator or in the case of an owner operator structure, conduct operations from the location.

Key Characteristics

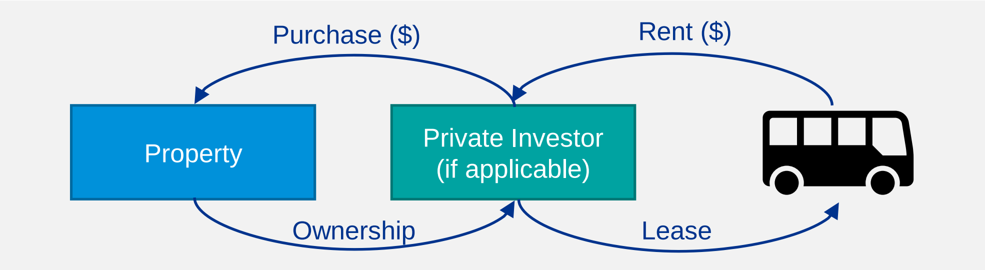
— Depots continue to be procured and owned by private individuals, companies or any other entity that is capable of owning property under New Zealand's property ownership framework.

— If applicable, the depots would be leased to the operator who would pay a regular rental payment in return for access and use of the depot.

— The depot owner would benefit from proprietary rights in the depots which could be pledged as security. This will improve the terms in which the depot owner would be able to raise finance.

— At the end of the lease term, the depot would be returned to the depot owner in a pre-agreed condition.

— All asset owning risk (e.g. utilisation, technology, residual asset value, maintenance) would be assumed by the asset owner.



Pros

— A private ownership model provides greater flexibility to operators to choose the location of the depots that best complements their routes. Location and accessibility to routes can have a material impact on the operating cost of a bus route and can impact the overall profitability of a business.

— As previously mentioned there is a strong correlation between bus operators and depot ownership in New Zealand with many operators already owning the depots they operate from.

— Maintaining the status quo for ownership will reduce the need for additional procurement.

— As the depots will remain in private ownership there is no capital requirement for Central / Regional Government.

— Any financing required to purchase the depots will sit on the balance sheet of the investors. If the depots owners default on their financing terms there will be no recourse back to the Central / Regional Government.

Cons

— Depot ownership may increase barriers to entry which in turn reduces competition. This is particularly relevant in situations where depots have been upgraded to support Zero Carbon Technologies, or when only short terms leases are available.

Key Considerations:

— Internal structuring is required to ensure appropriate experience, governance, and resource is available to procure and manage depot portfolio however in many instances appropriate governance is already in place.

— Location of depots significantly influences the cost of infrastructure upgrade (e.g. electrification) and route operating costs. Location may also influence what technology can be adopted as range and refueling capabilities of Zero Carbon Technology buses can be limited when compared to diesel incumbents. Once technology specifications have been confirmed, tailored/targeted property searches can be undertaken.

— Depot procurement and/or depot upgrades should complement any bus procurement strategy to ensure depot capacity supports fleet demands. Conversely, over-capitalisation should also be avoided.

— Implications in operating multiple fleets should be considered for any transition period.

— Historically there has been a high correlation between fleet, infrastructure and depot ownership. Removing this aspect may result in operators looking to other parts of their business for efficiencies (e.g. wages) which may result in conflicts with other Government strategic objectives.

Option Development

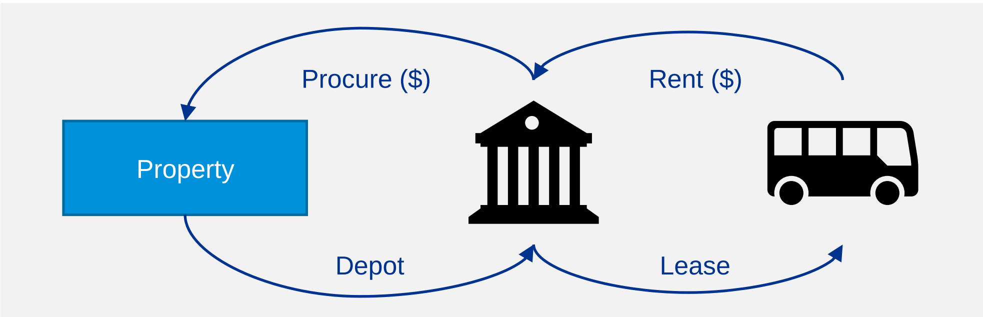
Ownership & Procurement - Depot - Centralisation

Overview

Under a centralised ownership structure, ownership in the depot would vest in either Central Government or Regional Government (i.e. regional councils, local councils and in Auckland, Auckland Transport).

Key Characteristics

- Depots would be procured (directly or through agent) and owned by Central or Regional Government.
- Assets would be leased to operators who would pay a regular rental payment in return for access and use of assets.
- At the end of the lease term, the asset would be returned to the asset owner (i.e. Central or Regional Government).
- As asset owner, the Central / Regional Government would benefit from proprietary rights in the depots which would enable the assets to be pledged as security. This may improve the terms in which the Central or Regional Government would be able to raise finance.



Pros

- Central ownership provides greater flexibility for the Central / Regional Government to select locations that suit its immediate and wider strategic objectives.
- Central / Regional Government can leverage its existing property network. Repurposing buildings where applicable will reduce the upfront capital required.
- Centralisation of ownership could assist with the long term planning of efficient bus routes.
- Depots could be bundled with routes therefore encouraging competition from operators that don't have existing depots.

Cons

- A significant upfront capital requirement is required to acquire/develop depots.
- As commercial property prices vary throughout the country it is difficult to quantify the total cost required to centralise depot ownership.
- Location of depots may not be in optimal position for operators, in terms of route and/or grid accessibility. This may reduce efficiencies and negatively impact operating costs.
- Centralisation of ownership would result in fewer aspects for operators to compete on which could result in decreased innovation and route efficiency.
- Central / Regional Government would need to take on additional risk associated with depot ownership (e.g. utilisation, maintenance etc.). In addition the Government would be exposed to movements in the property market.
- In order for this structure to be successful, strong incentives (e.g. favorable lease terms) or legislative / contractual requirements (e.g. depots provided under PTOM) would likely be required.
- Centralisation would require Government to undertake ongoing procurement and property management functions. Further consultation and stakeholder engagement would be required to establish where this function will be best managed from.

Key Considerations

- Central / Regional Government to consider whether additional risks associated with ownership (e.g. utilisation, maintenance etc.) are acceptable.
- Central / Regional Government to consider whether it has capabilities required for ongoing procurement and asset management requirements.
- The Central / Regional Government will need to consider the type of entity that it will use for ownership under a centralised structure. Refer Ownership & Procurement - Fleet – Centralisation for additional commentary.

Option Development

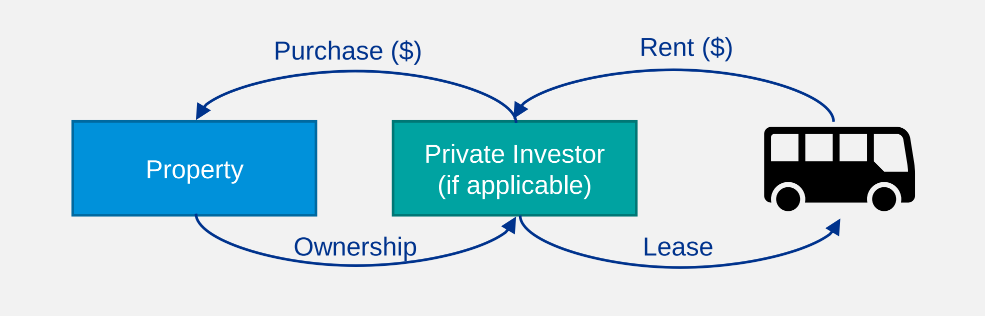
Ownership & Procurement - Infrastructure - Private

Overview

Zero Carbon Technology buses will require new infrastructure at depots and potentially along routes (for example charging stations). Under a private ownership structure, ownership in the supporting infrastructure (excluding power grid) would vest in private individuals or companies. This could take the form of power companies, operators or third party investors.

Key Characteristics

- Supporting infrastructure would be procured and owned by private individuals, companies or any other entity that is capable of owning infrastructure assets.
- Assets such as charging stations, back up generators energy management systems, would be leased to operators who would pay a regular rental payment in return for access and use of the asset(s).
- At the end of the lease term, the asset would be returned to the asset owner. Note this is only applicable to certain types of infrastructure (e.g. charging units / substations etc) that have the ability to be removed from site at the end of the lease term.
- All asset owning risk (e.g. utilisation, technology, residual asset value) would be assumed by the asset owner.



Pros

- Operators have greater visibility over their fleet procurement programme and requirements. This will enable investment in supporting infrastructure to align with wider procurement plans. By closely aligning infrastructure and bus procurement, operators can spread capital investment over a period of time, reducing the risk of excess capacity and unutilised assets.
- Private ownership provides greater flexibility for operators to select technology that best suits their fleet or route characteristics.
- Private owners would be able to access various capital sources (e.g. commercial debt, grant, lease finance, debt capital markets and equity) and would be encouraged to keep their cost of financing low.

Cons

- Many operators will not have the expertise for wide scale implementation of "out of depot" infrastructure (e.g. on route charging) therefore time delays will be incurred while companies upskill.
- The significant capital costs required to upgrade infrastructure can create barriers to entry. Public funding would potentially facilitate this and indirectly lead to less competition.
- Purchasing in smaller bundles will unlikely achieve same bulk purchasing discounts as a centralised procurement programme.

Key Considerations

- Upfront capital costs for supporting infrastructure can vary significantly depending on region, existing infrastructure and technology adopted. Further investigation and consultation with key stakeholders would be required to quantify the total capital requirement.
- If there are significant unknowns, private individuals or entities may not be willing to accept the risk associated with wide spread adoption.
- Out of depot infrastructure, specifically on route charging stations, may be required due to limited range of some Zero Carbon Technology buses. Close collaboration with regional/local authorities and operators will be required to establish who will own and/or be responsible for ongoing maintenance of the infrastructure and to ensure such infrastructure is installed in the optimal location so it can fit in with the wider strategic objectives of the authority.

Ownership & Procurement - Infrastructure - Centralisation

Overview

Under a centralised ownership structure, ownership in the supporting infrastructure (excluding power grid) would vest in either Central Government or Regional Government (i.e. regional councils, local councils and in Auckland, Auckland Transport).

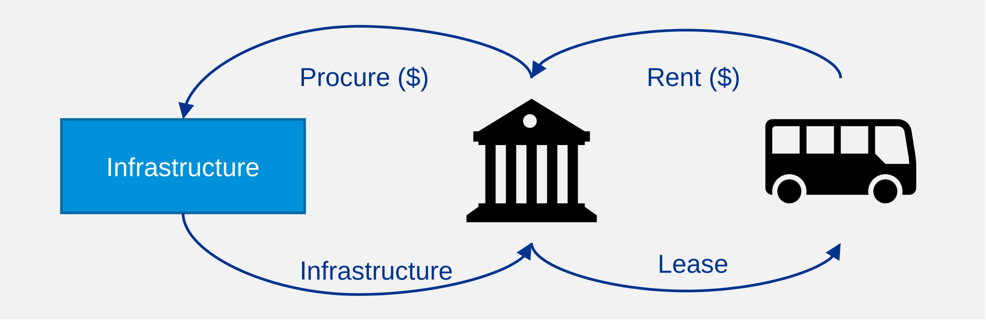
Assets would be leased to various operators and Unit holders.

Key Characteristics

— Supporting infrastructure would be procured (directly or through agent) and owned by Central or Regional Government.

— Assets would be leased to operators who would pay a regular rental payment in return for access and use of assets.

— At the end of the lease term, the asset would be returned to the asset owner (i.e. Central or Regional Government).



Pros

— Centralisation of ownership would enable standardisation of technology throughout the country/region. This could lead to additional efficiencies in terms of bus redeployment capabilities, especially for operators with a national presence.

— Centralisation would likely facilitate the accelerated roll-out of Zero Carbon Technology buses with infrastructure cost being a significant barrier to implementation.

— Centralising infrastructure procurement strengthens ability to negotiate bulk procuring discounts.

— Central / Regional Government can integrate infrastructure to achieve wider strategic initiatives.

— Infrastructure could be linked POTM contracts and could pass with Unit concession. This would encourage operators to concentrate on obtaining other operating efficiencies.

Cons

— Central / Regional Government may be limited in the technologies it can adopt due to interoperability with existing infrastructure. This is only relevant for regions that are already piloting Zero Carbon Technologies and have invested in a specific infrastructure (e.g. a type of charging station).

— Wide scale adoption will likely "lock in" a particular technology for a longer period of time as the cost to substitute given the scale of investment will be greater.

— A significant upfront capital commitment is required by the Government with installation and cost highly variable from region to region. Battery chargers cost an estimated NZD70,000 per 80kW charger, however other infrastructure investment and works required to connect to power networks vary significantly and require further investigation and consultation with appropriate stakeholders e.g. power company, engineers etc.

Key Considerations

— Widescale procurement and implementation may be limited by the lack of standardisation in the electric bus network. Interoperability between bus manufacturers and supporting infrastructure may limit supplier options.

— Location of electricity supply and local grid constraints is one of the main barriers to wide scale battery electric bus adoption. Network capacity and resilience upgrades must stay ahead of fleet procurement. Early involvement of local utilities and grid operators will assist with overcoming this obstacle.

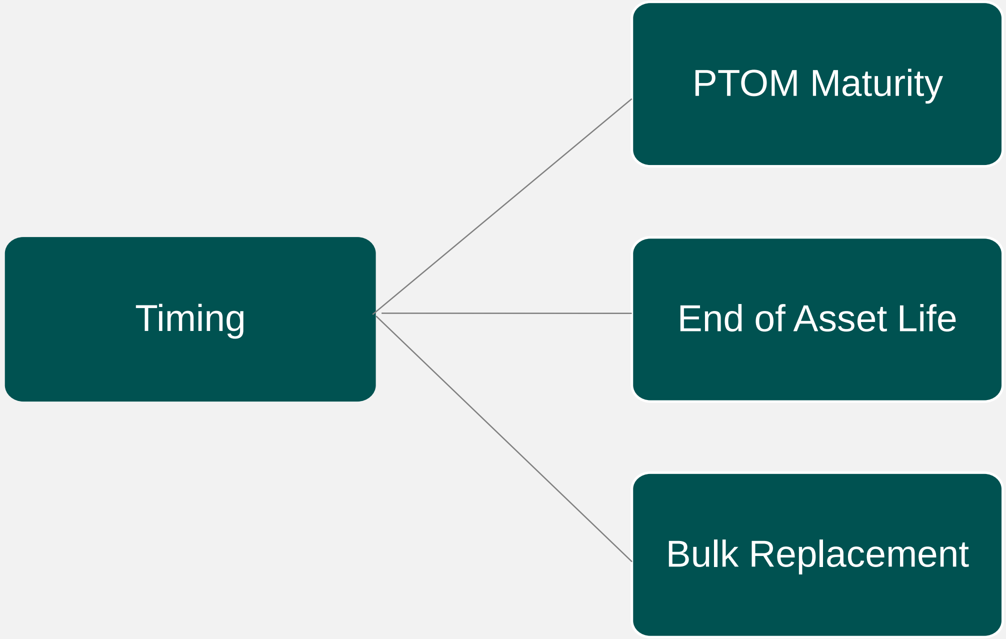
— The Central / Regional Government will need to consider the type of entity that it will use for ownership under a centralised structure. Refer Ownership & Procurement - Fleet – Centralisation for additional commentary.

Timing: Scope

Currently in New Zealand bus fleets are replaced by operators at the end of their economic life, which is often within the period of a PTOM contract. The PTOM framework and pricing structure allows for this.

Other jurisdictions that are transitioning to Zero Carbon bus technology have followed a range of approaches to the timing of transition depending on their governments' objectives (for example one jurisdiction has committed to be zero carbon by the time of a major international event), the age of the existing fleet and the readiness of the depots and associated infrastructure.

The diagram below sets out the three timing options this report considers and the following slides considers the implications of these in the New Zealand context. We recommend that all of these implications are tested and further explored with operators and Regional Councils.



Timing - PTOM Maturity

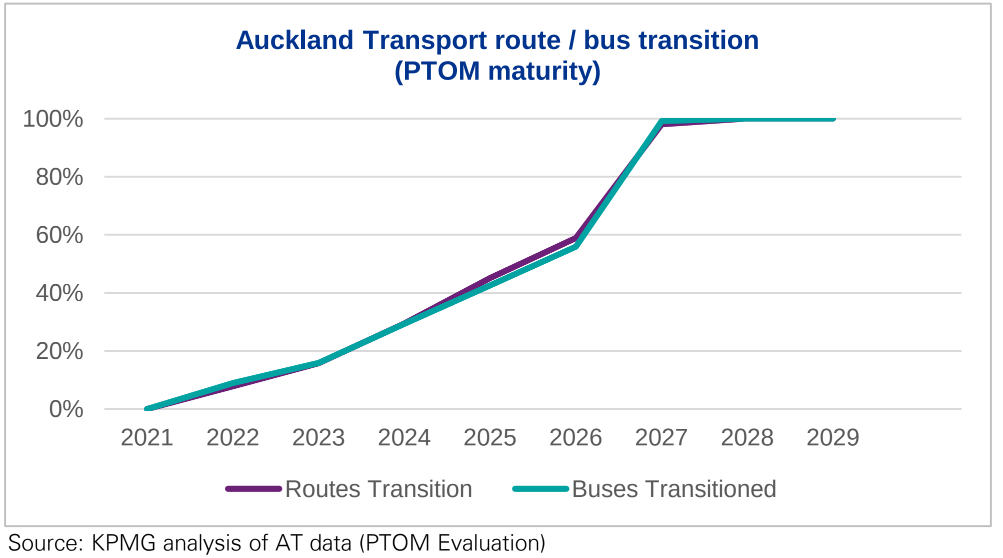
The government has set its zero carbon ambition within a 20 year horizon. This takes into account that many of New Zealand's diesel buses are relatively new and have a 20 year life. The options below set out different paces for transitioning to a Zero Carbon Fleet.

Overview

All new PTOM contracts or renewal of existing PTOM contracts are to be tendered / negotiated using Zero Carbon Technology.

Key Characteristics

- All PTOM contracts are to be procured with Zero Carbon Technology buses. The change in specification will not be applicable to existing PTOM contracts.
- New growth routes would automatically require Zero Carbon Technology to be applied .
- Operators will be notified of the upcoming change in specifications early to enable operators to manage their existing fleets and ensure no further diesel bus procurements occur. This could mean operators are allowed to run some existing diesel buses beyond their existing life, which is currently limited to 20 years under Requirements for Urban Buses, if safe to do so. There will also be some recently procured diesel buses that will still have useful life and may be seen ss stranded assets if they cannot be redeployed to other uses (not public transport).
- Using Auckland as a proxy for the country, under this model 100% of PTOM contracts can be transitioned to new Zero Carbon specifications and requirements by 2029.



Source: KPMG analysis of AT data (PTOM Evaluation)

Pros

- Many PTOM contracts have been negotiated or tendered in the past 2-3 years and as such will not be due for renewal for another 3 years minimum. This approach would enable gradual transition in the short term, facilitating a full transition well within the desired 20-year timeframe.
- As assets are replaced at the end of the existing PTOM contracts no mid-contract negotiations are required.
- The gradual transition would provide sufficient time for operators to upgrade depots and procure new fleets.
- As mentioned in "Fleet Ownership – Centralisation", delayed implementation would enable fleet owners to benefit from any technology development and decreasing prices.

Cons

- Recent tendering has resulted in operators procuring significant numbers of new buses that will have an economic life that exceeds the transition timeframe. This would mean some diesel buses would become obsolete, for the purposes of PTOM, and would need to be retired or repurposed earlier than anticipated. Operators will likely seek to recover the cost of these buses in any new contracts and/or pursue additional guarantees in new contracts to prevent future asset stranding.
- Operators may want buy-back guarantees or a funding contribution covering some or all of the residual value of new Zero Carbon Technology buses if contracts are not extended.

General comments

- The above transition timing assumes that all new PTOM contracts (negotiated or tendered) would be delivered using exclusively Zero Carbon buses. Alternative sub-options may be considered for example new contracts could be negotiated/tendered for a transition during the life of the PTOM contract rather than full replacement upon commencement of new contracts.
- Changes or exemptions to Requirements for Urban Bus could be considered to allow buses that are due to be replaced mid-PTOM contract to be replaced at the commencement of a new PTOM contract. This would provide operators with additional comfort when making the required capital investment.

Timing - End of Asset Life

Overview

Replacement of assets to a Zero Carbon Fleet will occur at the end of their economic life which is limited to 20 years under Requirement for Urban Buses.

Key Characteristics

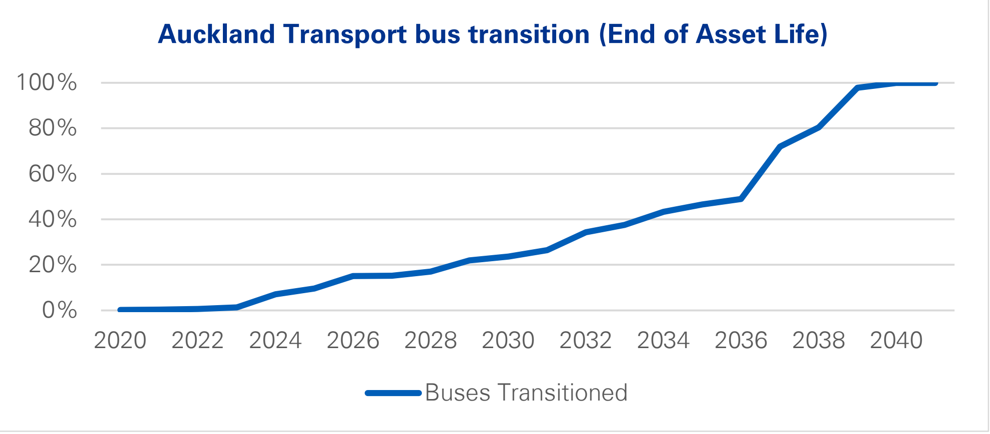
— New specifications set by central Government or Regional Councils require all buses to be replaced by Zero Carbon Technology at the end of their economic life under PTOM.

— Operators will be notified of this upcoming change early to enable operators to manage their existing fleets and ensure no further diesel bus procurements occur.

Pros

— Requiring assets to be replaced at the end of the asset life will enable a gradual transition to Zero Carbon Technology buses, while achieving the Government's ultimate goal of a full transition within 20 years.

— The gradual transition would spread the capital requirement over a greater period, noting many operators have recently acquired new diesel bus fleets. The table below demonstrates the timeline for transition for the Auckland bus fleet assuming replacement at the end of asset's economic life under PTOM.



Source: KPMG analysis of AT data (PTOM Evaluation)

— The end of life transition significantly reduces the residual asset risk (e.g. stranded diesel buses) of existing fleets as operators will transition buses at the end of their economic life. This reduces the likelihood that operators will seek compensation resulting from replacement.

— If safe and economically efficient, existing assets can be repurposed / redeployed in line with current practice.

— A transition at the end of the asset life enables existing Zero Carbon Technology buses to be trialled for longer periods with delayed implementation enabling fleet owners to benefit from any technology developments and reduction in prices.

Cons

— Contract variations are likely given asset life and PTOM contracts do not necessarily align. This may have significant cost implication for the Regional Councils who are responsible for the delivery of public transport in their regions.

— Many assets, e.g. +70% of Auckland's bus fleet, have a further 10+ years of useful life, resulting in a prolonged transition period.

— The slow transition of the fleet could mean the depots may need to operate as both diesel and zero carbon sites, which could increase cost and operational complexity.

— Operators may want buy-back guarantees or a funding contribution if contracts are not extended.

General comments

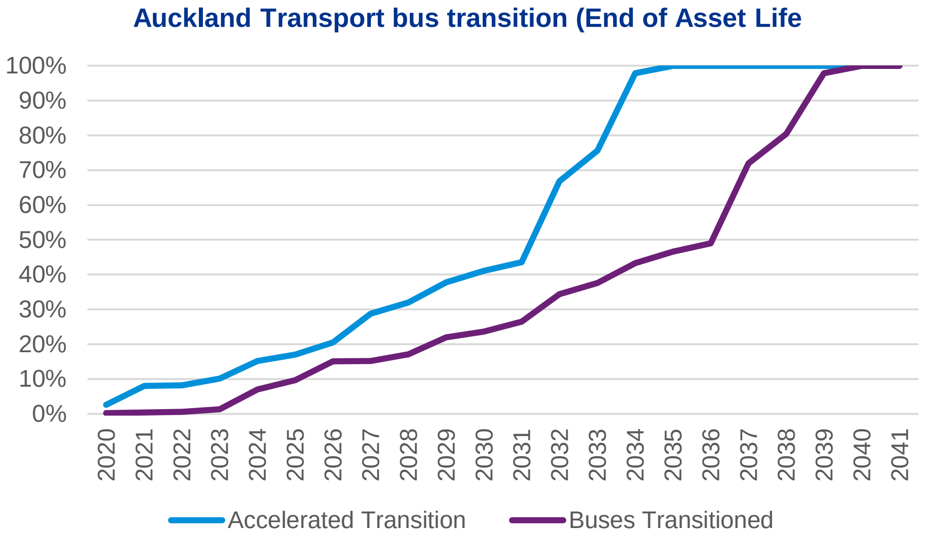
— The end of asset life transition is an option that would enable the government to achieve its goal of a full transition over a 20 year period, however tangible outcomes will not be evident in the short term.

— Operators of new fleets are likely to be more receptive of this transitional approach as it reduces assets stranding risk and allows for the recovery of costs, for previously incurred capital investment, to be made over the over the same period that was intended when the cost was incurred.

— As Requirements for Urban Buses restrict the age to 20 years, there is a natural replacement at the end of the economic life. Limited structural change would therefore be required to update the specification of any replacements.

Timing - End of Asset Life

— Variations to this option could also be considered, for example an accelerated end of life transition where diesel buses are replaced after 15 year (rather than 20). This would see the transition curve brought forward and would facilitate increased transition over the short to mid term.



Source: KPMG analysis of AT data (PTOM Evaluation)

Timing - Bulk Replacement

Overview

Bulk fleet replacement would see accelerated transition of the fleet in the short term (e.g. 3-5 years).

Any changes in contract would be negotiated with operators.

Key Characteristics

- Significant change in policy requiring bulk replacement of the entire fleet within a short timeframe.
- Operators will be required to replace vehicles at a specified time regardless of asset life or contract maturity.

Pros

- A bulk replacement approach would enable an accelerated transition to Zero Carbon Technology buses far exceeding the Government’s 20 year timeframe.
- Accelerated procurement would likely enable fleet owners to negotiate bulk procuring discounts.
- Zero Carbon Technology fleets require additional floor space due to additional infrastructure required to operate e.g. charging units, substations etc. Bulk transition will reduce the requirement to operate multiple technology buses from the same depot which will decrease operational complexity for operators.

Cons

- Bulk replacement of the fleets is unlikely to align with existing PTOM contract maturities which have been contracted using a specific technology. Widespread contract variations are likely under a bulk replacement scenario which will have significant legal and contractual costs to Regional Councils.
- Fast adoption would likely require significant Government capital support with smaller operators unlikely to have the financial capability to execute an accelerated transition.
- The relatively young age profile of New Zealand's existing diesel bus fleet would result in significant orphaned assets for operators.
- Zero Carbon Technology requires upgrades to supporting infrastructure which needs to occur prior to the buses being put into operations. Without the necessary infrastructure upgrades buses will be unable to operate.
- To date there has been limited adoption and trials of zero carbon technology in New Zealand. The rapid transition could see operators locked into a particular technology that is either incompatible or unfit for purpose. This increases the risk that additional expenditure will be required to replace or upgrade technology sooner than anticipated.

General comments

- Bulk replacement will require the procurement of 2,500+ buses and supporting infrastructure over a condensed period. The existing supply chain may have limited capacity to deliver scale.

D

Funding & Financing

Funding & Financing

Scope

For the purposes of this report, "funding" refers to a payment that does not need to be repaid (e.g. Government payment to operators) and "financing" refers to a flow of funds that must be repaid (e.g. an operator borrowing from a bank). Generally for PTOM bus services, the assets are funded as part of the operating payment made by Regional Councils or AT (co-funded by NZTA) and any financing is at the discretion of the individual operators.

For Zero Carbon Technology trialled in New Zealand to date, there have been some instances of one-off Government grants to support the upfront purchases.

Due to the significant capital required to implement a wide scale transition to Zero Carbon Technology, alternative funding and financing methods should be considered to supplement the existing model which would enable the substantial capital requirement to be shared across various interested stakeholders.

The scope for Funding & Financing refers to options in which the Government and/or other interested parties can raise the capital required to support the implementation of Zero Carbon Technology buses for use in urban public transport, using established models but also looking at other innovative solutions.

The options presented in this section of the report are not mutually exclusive, i.e. it could be possible to use a combination of them.

Based on this scope the following funding and financing structures have been identified:

1. Operator Financing;
2. Central Government Grant / Loan;
3. Asset Owning Special Purpose Vehicle (SPV);
4. Targeted Levy; and
5. Component Finance / Lease Model.

In assessing funding and financing solutions, consideration should be given to the five C's which lenders will typically look to when gauging borrower creditworthiness. These factors ultimately define debt capacity and will influence what pools of liquidity are potentially available to the borrower.

Capacity
— What is the borrower's ability to repay debt?

Capital
— How much capital can the borrower contribute to the investment?

Collateral
— What collateral can the borrower provide to secure the loan?

Character
— What is the borrower's credit history and track record for repaying debt?

Conditions
— What is the purpose of the loan?
— When will the loan be repaid?

Options - Operator Financing

Overview

Bus operator finance largely reflects the status quo in New Zealand. Under PTOM, regional councils (and in the case of Auckland, Auckland Transport) develop a Regional Public Transport Plan (RPTP). This sets out the region's network and objectives, plans the required services, and allocates them into "Units".

These Units are then procured from the market with operators required to provide fleet and depot facilities according to the Unit specifications (although in some cases depot facilities are leased from the Regional Council).

An operator financing structure places the requirement to raise finance and make capital payments required for procurement of any necessary assets required to operate a Unit, onto the operators.

Key Characteristics

- Operators are responsible for securing their own finance required to purchase (or lease) the assets required to meet the Unit specifications.
- Operators may finance this procurement through a variety of options including but not limited to shareholder contributions, commercial bank debt, or operating cash flows of the business.
- The cost to acquire assets are generally recovered (or partly recovered) over time through the PTOM contract rates paid by Regional Councils or AT (co-funded by NZTA).
- They are likely to try to recover their investment over the course of the PTOM contract, unless there is high certainty that the contract will be extended or there are arrangements for the operator to sell or redeploy the assets on completion.
- This is the current method for funding and financing diesel buses.

Pros

- The primary benefit under a bus operator financing structure is that there is no upfront capital requirement from the Central / Regional Government to purchase assets required to operate a Unit.
- The responsibility of securing finance required to purchase (or lease) any necessary assets is passed to the operators.
- All debt raised in relation to the purchase of assets will sit on the balance sheet of the operator and will not impact Central / Regional Government's debt ceilings (refer Target Levy for additional commentary of debt ceilings).
- All debt servicing requirements (e.g. principal and interest) remain the responsibility of the Operator and there is no recourse back to the Central / Regional Government if the operator breaches the terms of its financing arrangement(s).
- Refinancing risk will be the responsibility of the borrower, not Central or Regional Government.
- Operators will in almost all cases have existing relationships with one or several lenders and are also likely to have credit facilities already in place. These relationships and pre existing agreements could facilitate shorter times to arrange finance.
- No significant policy or legislative changes are required to continue with a bus operator financing structure.
- The structure is already adopted in the market and is applied on a national level.

Cons

- Lenders will look to the underlying credit profile of the operator when making their assessment on how much they are willing to lend and at what price. Operators will likely have a weaker credit profile than the Central / Regional Government and as such the cost to finance will be higher than if the Central / Regional Government was to raise the funds itself.
- Higher cost of borrowing will be indirectly passed to the Regional Authority and recovered through the PTOM contract rates paid by Regional Councils or AT (co-funded by NZTA).
- When assessing debt capacity of a prospective borrower, lenders will look to the size and strength of the borrower's balance sheet. A weaker balance sheet (e.g. low equity, high existing debt, poor asset quality amongst other factors) may mean that lenders may be unwilling to extend further credit to the borrower. Without sufficient credit facilities in place, an operator's ability to procure new assets will be restricted and will impact their ability to transition to a Zero Carbon Technology fleet within the Government's timeframes for transition.
- Tenor of debt (i.e. the length of time lenders will be willing to provide credit facility for) will typically be for a period of 3-5 years. As the current PTOM contracts range from 6-9 years there is a misalignment of maturities. Operators will need to continue to manage this risk to ensure they have appropriate funding and/or financing in place to enable them to meet their obligations under their respective PTOM contracts.

Options - Operator Financing cont.

General Comments:

- Bus operator finance largely reflects the status quo in New Zealand and is already in place throughout the country.
- No material changes to the existing PTOM framework are required.
- Operators are limited in the amount of debt they can raise. If sufficient financing can not be raised, both in terms of quantum and in a timely manner, an operator's ability to implement the Government's zero carbon technology initiative within the prescribed timeframe will be impaired. It is recommended that further investigation into operators' financial capacity is undertaken to establish whether operators have sufficient financial means to undertake the contemplated transition to Zero Carbon Technology buses with in the prescribed timeframe.
- In addition to operators' financial capacity, further clarification regarding the period in which operators seek to recover their investment in new buses is required. Shorter periods may benefit from alternative credit or structural enhancement from the Central Government which may lengthen and/or cheapen financing terms making a transition to Zero Carbon Technology buses more economically viable. Refer "Options - Central Government Grant" for additional commentary.

The cost and terms of financing under a bus operator financing structure will vary significantly depending on the individual circumstances of the borrower. In most instances bus operators will borrow money from the New Zealand domestic bank market. The following table provides a high level overview of terms and key considerations that lenders will consider when assessing a credit application:

	Definition	Comment
Borrower	The entity that will be entering into financial arrangements with lenders.	- The borrowing entity will depend on the corporate structure of the individual bus operator. - In many instances the entity will be a limited liability company and responsible for all trading activities of the business.
Tenor	The length of time until a loan is due.	- In the New Zealand bank debt markets, lenders are generally willing to provide loans or credit facilities with a tenor of 3-5 years. - This can be extended in limited circumstances, however to do so will require significant due diligence and a robust contractual framework. - At the end of the tenor, the borrowing entity will need to repay or refinance any loan that remains outstanding.
Leverage	The ratio of an entity's Debt to Equity or EBITDA[1].	- Entities with higher leverage generally have less ability to incur additional debt. - Lenders will likely require c20-50% of total assets to be funded by Equity.

Financial Covenants	Undertakings given by a borrower as part of a loan agreement.	- The purpose of a financial covenant is to help a lender ensure that the risk attached to the loan does not unexpectedly deteriorate prior to maturity.
		- Covenant will vary depending on the borrower and lender. Typical covenants for borrowers such as a bus operator include:
		    - Leverage (Net Debt[2] to EBITDA)
		    - Interest Cover (Interest costs to EBITDA, or EBIT[3])
		    - Debt Service Coverage Ratio (Operating cash flow / Debt Service Costs e.g. Principle + Interest)
		- Breaching a covenant will result in remedy actions which can include immediate repayment of the loan, increased interest rates, restricting business operations.

Collateral	Something pledged as security for repayment of a loan.	- Borrowers can provide collateral to allow them to borrow larger amounts and have access to cheaper financing. Lenders take comfort that in a default situation they will get repaid from the sale of that collateral. - Collateral that is highly liquid (i.e. can easily be converted to cash) and whose value is not volatile (e.g. property or government bond) is considered higher value than assets that will take less time to convert to cash or is subject to high volatility.
Pricing	Variable.	- Pricing is dependent and will be determined by the underlying credit profile of the borrower. - Entities with a lower credit profile can expect a higher cost of financing than higher rated entities.

1. Earnings before interest, tax, depreciation and amortisation
2. Total debt less cash on hand
3. Earnings before interest and tax

Options - Central Government Grant / Loan

Overview

As previously discussed, there is significant upfront capital costs required to procure a new Zero Carbon Technology fleet and supporting infrastructure. The capital requirement, coupled with operator financial constraints, has been identified as a barrier that has prevented wide spread adoption to date.

In order to facilitate an accelerated transition, the Government could look to various support measures that would either reduce the upfront capital burden for operators or lower ongoing operating costs to make a transition more economically viable. These can include but are not limited to grant funding, guarantees, longer PTOM contracts, favourable loans, financial incentives (e.g. tax credits) or residual asset guarantees. The mechanism that would facilitate a transition to Zero Carbon Technology in the shortest timeframe with the least impact to the existing operating framework is Government grant funding.

Key Characteristics

— Central Government provide grant funding to assist with the acquisition of Zero Carbon Technology buses and supporting infrastructure. The amount of any grant can be tailored to fit the Governments wider strategic objectives.

— Grant Funding will be provided to operators who demonstrate the use of proceeds will be applied to the Governments decarbonisation initiative.

— If the assets are to be owned outside of Government (e.g. by the Operators), the grant would not give the Government any ownership rights in the assets.

Pros

— The awarding of grants to operators would likely accelerate the procurement and subsequent transition to Zero Carbon Technology by reducing the capital burden on operators.

— Central Government generally have access to a lower cost of capital than lower rated private entities. As a result, the overall costs to fund and finance the purchase of assets will be lower when compared to private funding and financing options.

— As Central Government would provide a grant to facilitate the procurement of assets, there should be no impact on contract rates for route operation. If anything, ongoing contract rates would decrease because current rates include the cost of owning the diesel fleet.

— Material changes to the PTOM framework would not be required with Units continuing to be procured from the market on the basis that operators provide fleet and depot facilities.

Cons

— A Central Government grant funding structure would require significant upfront capital contributions from the Central Government. The internal funding requirement would need to be balanced against other Central Government priorities.

— As any payment from the Government would be grant funding, the Government would not gain any ownership interest in the assets despite providing capital to assist with the purchase.

— Strict criteria and visibility of use of proceeds would be required to ensure funding is applied to its intended purpose and that there is no value leakage.

General Comments:

— A Central Government grant funding structure is a way that the Government can reduce the capital burden on the private sector and accelerate the transition to Zero Carbon Technology buses.

— No material changes to the existing PTOM framework are required and there are limited barriers to apply the strategy throughout New Zealand.

— As operators are limited in the amount of debt they can raise, Government grants can be an effective way to fund the price differential between diesel and Zero Carbon Technology buses or the buses in their entirety.

— Without this support, an operator’s ability to implement the Government’s Zero Carbon Technology transition within the prescribed timeframe will be impaired.

Options - Central Government Grant / Loan cont.

The borrowing capacity of entities is an important factor that the Ministry should carefully consider when evaluating alternative options to transition to a Zero Carbon Technology fleet. Many entities will be restricted in the amount of debt they can incur which ultimately influences the speed in which they can execute strategic initiatives, specifically those that have large capital requirements. Credit and structural enhancements are alternative ways entities can improve their credit profile which will lead to more favourable borrowing terms. The following table outlines several ways in which the Central/Regional Government can support entities in accessing cheaper and longer term financing:

Capital Support	• Higher leverage transactions are considered riskier by lenders and will attract a higher cost of capital (e.g. higher interest margins). • Capital support by the Government will decrease the amount of financing required to purchase assets which will have positive impacts on the underlying credit profile of a borrow and the overall cost of financing.
Guarantee	• Guarantees from higher rated entities enable lenders to transfer risk from a borrower to the higher rated guarantor. This enables lenders to advance credit on more favourable terms (e.g. lower margin, longer tenor etc) and also influences the size of loan they may be willing to advance. • Guarantors will need to record this contingent liability on their balance sheet. In the case of the Government or more specifically the Regional Government, this may affect its debt ceiling calculations and credit rating, which may impact the cost in which it can raise capital.
Tax Credits	• Tax credit reduce the tax obligation of a entity to the Government. • Unlike deductions and exemptions, which reduce the amount of taxable income, tax credits reduce the actual amount of tax owed. • Reduction of tax obligations assist with cash flow and enables capital to be applied to other investment opportunities.
Long Contract Tenors	• Long term contracts between a borrower and its customers provide lenders with additional comfort on future cash flows. • Lenders will take particular comfort with long term contracts to highly rated entities (e.g. Regional Government) where the probability of defaulting under the contract is considered low.
Residual Asset Risk	• Lenders who provide finance that is specifically linked to a particular asset will ensure loans are repaid prior to the end of the economic life of the asset. • If a borrower can mitigate residual asset risk (for example through a Government buy back arrangement) lenders will be able to align financing tenors with asset life.

Options - Asset Owning Entity or Special Purpose Vehicle

Overview

Under an Asset Owning Entity or Special Purpose Vehicle structure a special purpose vehicle is established to procure a bus fleet and supporting infrastructure assets on scale from manufacturers.

The special purpose vehicle would then lease these assets to various operators.

The special purpose vehicle is intended to run independently of operators.

Key Characteristics

- The sponsor of the initiative, which could comprise of one or a combination of the Central or Regional Government, an operator, or a third party investor, will establish a special purpose vehicle.
- This special purpose vehicle will have three main functions:
  - Procurement of assets: The special purpose vehicle will be responsible for asset procurement and all responsibilities and obligations associated with performing this function (e.g. choosing specification, ordering, making payments, arranging delivery etc).
  - Financing: the special purpose vehicle will be required to arrange and manage the financing required to purchase the assets. The special purpose vehicle can obtain various sources of financing or funding to achieve this. Financing options may include (but are not limited to) bank debt, Government grants, shareholder contribution, bond issuances.
  - Leasing of assets: the special purpose vehicle will lease the assets to bus operators throughout New Zealand. The operators will make periodic lease payments back to the special purpose vehicle. These lease payments will be the revenues for the special purpose vehicle and will be used to cover expenses related to the operations of the special purpose vehicle and repayments of any financing incurred to assist with the purchase of the assets.
- The special purpose vehicle is intended to be an asset owner and leasing entity only and would not hold contracts to operate Units under PTOM.
- As procurement would be on scale, bulk purchasing discounts may be negotiated.

Pros

- As with a Bus Operator financing structure there is no upfront capital required from the Central / Regional Government to purchase assets required to operate a Unit.
- The responsibility of securing the finance required to purchase (or lease) the assets sits with the special purpose vehicle.
- All finance raised in relation to the purchase of assets will sit on the balance sheet of the special purpose vehicle. There will be no recourse back to the Central or Regional Government in the event of default and will therefore not impact the Central or Regional Governments debt ceilings (refer Target Levy for additional commentary of debt ceilings) (note: this position to be confirmed with the rating agencies when structure is being established).
- The special purpose vehicle has freedom to use various financing instruments (e.g. bank loans, equity, grants etc.) and will be incentivised to access the cheapest financing available.
- Assuming financing is required, any finance raised by the special purpose vehicle will be ring-fenced from any Central / Regional Government so will not contribute to any Central or Regional Government debt ceiling ratios (refer targeted Levy for additional commentary).
- As the finance will be sitting in a special purpose vehicle there will be no recourse back to the Central / Regional Government if the borrower defaults on its debt obligations.
- If the special purpose vehicle is 100% state-owned, a lender may "look through" to the Government when assessing the risk of the borrower. This will have a positive impact on the cost of capital that lenders are willing to provide.

Cons

- As the special purpose vehicle is a standalone entity, its credit profile will be less than the Central / Regional Government. This means the cost of its finance will be higher than if the Government was to raise the finance itself. Financing terms and conditions will be influenced by various factors which include:
  - Strength of cash flows: What are the contract tenors? Who are the contracts with? Are revenues streams diverse or is there concentration risk?
  - Strength of balance sheet: What is the quality of the special purpose vehicle's assets? How much debt does the special purpose vehicle already have? How much equity is in the business? What is the asset value / assets life that the lender is taking security over?

Options - Asset Owning Entity or Special Purpose Vehicle cont.

- Management and governance: Does the management have sufficient expertise / track records to manage operations?

- The special purpose vehicle is heavily reliant on 1) incumbent operators successfully re-tender/negotiation of Units on maturity and/or 2) being able to re-lease its assets to any new operators in the event the incumbent is not successful. As a result there is a considerable amount of uncertainty beyond the immediate PTOM contract tenor (e.g. 6 or 9 years) from both an asset stranding and future cashflow perspective. Lenders will factor this into their risk assessment which will likely increase the cost of any finance but may also result in aggressive repayment profiles which can place considerable strain on the cashflow of the special purpose vehicle.
- Due to the relatively small cost to procure individual buses (cNZD750,000 per vehicle), there is unlikely to be a sufficient financial barrier for operators to exclusively lease assets off the special purpose vehicle with operators continuing to procure buses themselves. This may result in asset stranding for the special purpose vehicle and is a key risk that needs to be considered. To be successful, changes to the market structure would likely be required linking assets to PTOM contract. Alternatively, leasing rates would need to be set/subsidised to levels in which fleet ownership by operators is uneconomical when compared to leasing the assets from the special purpose vehicle.
- If the special purpose vehicle is unable to demonstrate certainty of revenues (e.g. the lease payment from operators) its borrowing capacity will be limited and additional equity may be required to fund its capital expenditures.

General Comments

- Strong market push back is likely as operators currently own their bus fleets and are exposed to significant asset stranding if the above structure is adopted.
- For this structure to be successful, strong incentives (e.g. favorable lease terms) or legislative / contractual requirements (e.g. buses provided under PTOM) would likely be required.
- While maintenance obligations would sit with the asset owner (i.e. the special purpose vehicle) by default, these obligations can be contracted out to the lessees (i.e. the operators). Operators would then be responsible for the asset maintenance and would be required to return the asset(s) back to the special purpose vehicle in an agreed condition at the end of the lease term.
- If the special purpose vehicle is 100% state owned, the Central / Regional Government will need to consider the type of entity that it will use for ownership. Refer Ownership & Procurement - Fleet – Centralisation for additional commentary.

Options - Targeted Levy

Overview

Traditionally the upfront costs for large scale infrastructure projects have been funded through Central or Regional Government's income (usually collected by rates) or borrowings (usually secured by future rates).

Regional Governments are subject to debt ceilings, which if breached can result in credit rating downgrades. Maintaining credit ratings is extremely important as negative movements will impact the quantum and price price of debt that the entity can borrow in the future.

These debt ceilings take various forms including Local Government Funding Agency debt-to-revenue covenants, and local authority's financial strategy (which under the Local Government Act 2002 must include quantified borrowing limits).

A targeted levy structure is a public funding mechanism, that enables the upfront capital cost, and in many instances the public borrowing requirement, of an investment to be moved to the private sector. The revenues required to meet the costs of that investment are then raised through the imposition of a levy on a specific catchment in the community that is deemed to be closely related to that investment and will receive some sort of benefit.

The Infrastructure Funding and Financing Bill would facilitate the use of a levy, but in its current form may not allow for vehicle fleets. This should be considered further with DIA.

Key Characteristics

The following sets out a high level description of how procuring a fleet of Zero Carbon Buses and/or supporting infrastructure could be structured utilising a Targeted Levy Structure.

- The sponsor of the initiative, either Central or Regional Government or a Bus Operator, will establish a special purpose vehicle that will be responsible for raising the necessary finance (debt and equity) for a particular capital investment.
- The special purpose vehicle will source debt from private providers and use the proceeds of that debt to procure the assets and supporting infrastructure from the manufacturers.
- The revenues that will be used to service the debt (i.e. principal and interest payments), will come via a levy, which is collected on behalf of the special purpose vehicle by the council, and can be supplemented by other sources of income such as asset lease receipts.
- The levy itself will be imposed on a particular catchment in the community that is deemed to benefit from the investment. For example, residential / commercial properties that are impacted by high vehicle pollution levels or would gain some economic benefit from a new bus route.
- The levy will be ring fenced and can only be applied to the specific investment.
- The assets would be leased to operators with rental payments used to supplement the levy.

Pros

- As with other financing structures there is no upfront capital required from the Central / Regional Government to purchase assets required to operate a Unit.
- The upfront capital required to purchase the Assets is met by the private sector.
- Assuming financing is required, debt raised by the special purpose vehicle will be ring-fenced from any Central / Regional Government debt so will not contribute to any debt ceiling ratios.
- Debt repayment would be non recourse to the Central / Regional Government.

Cons

- To implement a targeted levy structure legislative changes would be required as is being seen with the Infrastructure Funding and Financing Bill.
- Imposition of levy on people or businesses within a catchment is politically challenging and would require substantial consultation with the market before it could be implemented.
- Those captured under the levy, particularly those on fixed incomes, might not be able to afford the levy and/or may feel there is limited direct benefit to them.
- There is uncertainty as to if or when a target levy structure could be implemented in the context of urban buses. Implementation would require either new legislation to be passed into law or amendments to the Infrastructure Funding and Financing Bill to allow for public transport to be included within its scope.

General Comments

- Offshore, targeted levy structures have been successfully implemented however there has generally been a strong economic benefit identified from the capital investment that is used to identify the catchment area.
- To date there has been no successful implementation of a Targeted Levy structure in New Zealand. Similar structures have been trialled however there are many distinguishing factors. E.g. the Milldale property development.
- In the context of bus and supporting infrastructure investment, defining the catchment area will be both practically and politically challenging and will require significant consultation with councils and impacted stakeholders.

Funding & Financing

Options - Lease

Overview

To reduce the initial capital cost of a bus, fleet owners or operators can look to lease part or all of a vehicle from manufacturer or leasing companies, thereby spreading the total cost over a greater period.

Key Characteristics

- — Bus operators will lease the assets from the manufacturers or assets owners.
- — Assets can look to lease the entire bus or specific componentry (e.g. the battery).

Pros

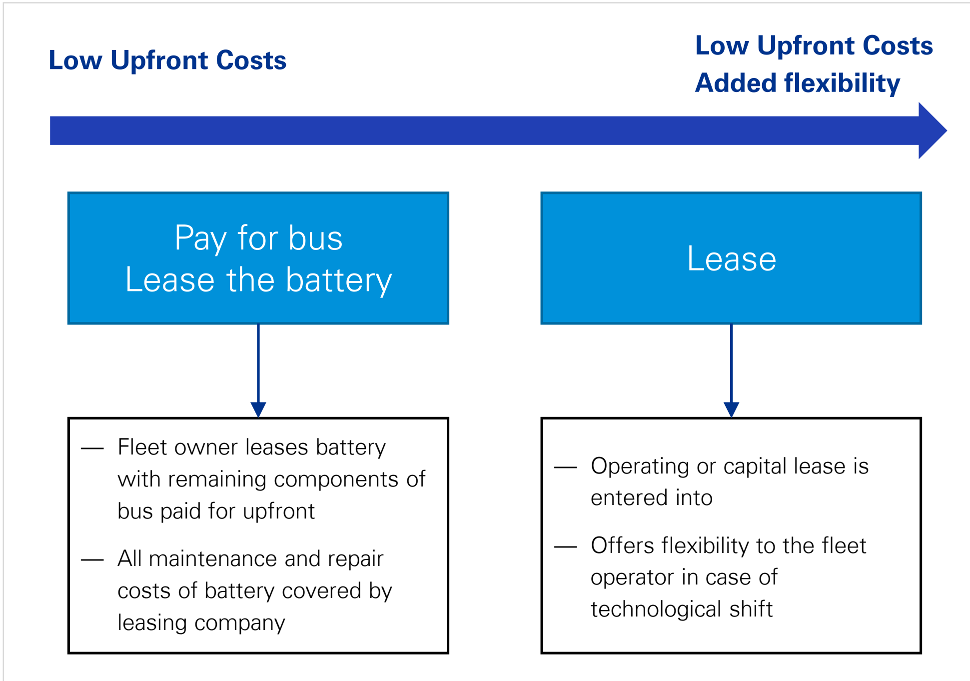
- — Leasing componentry such as the battery can bring the initial capital costs of a Zero Carbon Technology bus to a similar level as a diesel bus. Whilst the initial capital requirement is less than purchasing outright, leasing can be seen as a form of financing and the whole-of-life cost would likely be higher than an outright procurement.
- — Lease arrangement allows the cost of the bus/battery to be spread over a greater period. Lease terms are subject to negotiation with the lessor however can range from short term to the life of the asset.
- — The upfront capital cost under a leasing arrangement is significantly reduced as third parties are providing the finance to access the asset(s).
- — Capital costs can be spread across multiple parties (i.e. Government, supplier, operator).

Cons

- — Scalability of such an initiative may be limited for smaller manufacturers.
- — Terms of lease are linked to the credit profile of the lessee.
- — Entities with lower credit ratings may pay higher lease costs.
- — The whole of life cost can be greater than purchasing the assets outright. These cost will likely be indirectly passed to the Regional Government through the PTOM contact subsidy.

Key Considerations

- — Implementing a wide scale leasing financing structure would be difficult to achieve and would need to be market driven to be successful.
- — Operating lease models for Zero Carbon Technology buses have been trialled in foreign jurisdictions however the model is not fully tested in the New Zealand market.



Case Study

Refer case study 1

Options - Lease cont.

There are different leasing options available in the market. The two primary lease arrangements are Operating Leases and Financial Leases (sometimes referred to as capital leases). The following table provides a high level overview of terms and key differences between the two options.

	Operating Lease	Financial Lease
Overview	— An operating lease is a contract that allows for the use of an asset but does not convey ownership rights of the asset. — Operating leases are considered a form of off-balance-sheet financing - meaning a leased asset and associated liabilities (i.e. future rent payments) are not included on a company's balance sheet.	— A finance lease (also known as a capital lease or a sales lease) is a type of lease in which a finance company is typically the legal owner of the asset for the duration of the lease. — The lessee has operating control over the asset, and also some share of the economic risks and returns from the change in the valuation of the underlying asset.
Purchase Option	— There is no purchase option within the operating lease arrangement. — The lessee will return the asset to the lessor at the end of the lease period.	— A purchase option will be included in the lease agreement. — The lessee will have the option to purchase the asset at the end of the period.
Ownership	— Ownership of the asset will remain with the lessor at the end of the lease period.	— Ownership of the lease asset will be transferred to the lessee at the end of the lease period (if purchase option is exercised).
Expenses	— The lessor will be responsible for maintenance and repairs unless contracted out.	— The lessee will be responsible for maintenance and repairs.
Usual length of lease	— Part of useful lifespan.	— Most of useful lifespan.
Tax Benefit to Lessee	— Depreciation expense cannot be used to offset tax liability.	— Depreciation can be charged on a leased asset and used to offset tax liability.
Balance sheet treatment	— Does not sit on balance sheet.	— On balance sheet.

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Case Studies

Case Studies

Please note that at the time of writing, the ongoing COVID-19 pandemic has severely constrained access to transit operators and agencies, limiting the level of detail that can be provided here.

Quad Cities, USA – Case Study 1

Key aspects

- Battery-Electric Bus
- Central Ownership
- Lease

Location	Quad Cities, USA
Summary	 The Rock Island County Metropolitan Mass Transit District (Metrolink) have made successive investments in battery electric buses in 2018 (three vehicles) and 2019 (five vehicles) to replace existing CNG buses. To mitigate the risk posed by uncertainty of battery life, Metrolink have leased the batteries under a 6-year contract with ProTerra.
Investment	8 battery electric buses and supporting depot recharging infrastructure at a cost of around 640,000 USD per bus and 45,000 USD per depot charger. Funding support was provided from the US government for the 5 latest buses (3.2 million USD). A further 9 buses are planned for the near future.
Operating Model	Bus network planned and operated by the transport authority (Metrolink).
Ownership Model	Owned by the transport authority (Metrolink), batteries leased from the manufacturer (ProTerra)
Outcomes	— Ongoing investment in battery electric buses. — Carbon emissions reduced by around 330 tonnes by late 2019.

Sydney Airport Australia – Case Study 2

Key aspects

- Battery-Electric Bus
- Private operator

Location	Sydney Airport, Australia
Summary	 The largest electric bus fleet in Australia has been operating a car park shuttle service at Sydney Airport since 2016. Business plan was based upon achieving sustainability objectives and fuel cost savings and is within 1-2 years of achieving payback.
Investment	Six battery electric buses and supporting depot infrastructure at a cost of around 500,000 AUD per bus and 1,000,000 AUD for charging infrastructure (including a new substation). Use of a local supplier to help de-risk the use of 'new' technology by easing access to technical and warranty support.
Operating Model	Operated by a private operator (Carbridge) under contract to Sydney Airport.
Ownership Model	Owned by Sydney Airport.
Outcomes	— Has achieved target energy efficiencies and reliability, building confidence in electric power to the extent that the airport now intends to electrify most of its vehicles over the next few years.

Case Studies cont.

Toronto, Canada – Case Study 3

Key aspects

- Battery-Electric Bus
- Centralised Ownership

Location	Toronto, Canada
Summary	 Toronto Transit Commission ("TTC") has committed to steady-state procurement of zero emission buses by 2025 in line with the C40 Fossil-Fuel-Free Streets Declaration and an all zero emission bus fleet by 2040. To achieve this goal, TTC has committed to procure zero-emission buses to replace its current fleet of almost 2,000 predominately diesel powered buses.
Investment	To date, TTC has approved funding for the procurement of 60 battery electric buses (e-buses) and supporting infrastructure. This project requires federal funding in order for TTC to be able to deliver on its commitment for a steady procurement of zero-emission buses by the end of 2025.
Operating Model	Operated by Toronto Transit Commission
Ownership Model	City of Toronto
Outcomes	— TTC has procured 60 e-buses from 3 suppliers and has begun its pilot study and is gathering benchmarking data. Following completion of the pilot (late 2021), TTC intend to procure c160 buses p.a. with a total fleet size of c2,300. TTC e-bus strategy is estimated to have a total Net Present Value cCAD11.6bn coving the period 2019 to 2040.

London United Kingdom Case Study 4

Key aspects

- Fuel Cell Bus
- Centralised Ownership

Location	London, UK
Summary	 Transport for London (TfL) and their contractor Tower Transit have been running zero emission hydrogen fuel cell buses on routes RV1 and then 444 since 2011. The hydrogen fleet has been built up in several tranches under successive European schemes, most recently CHIC and 3Emotion.
Investment	10 fuel cell buses and supporting depot refuelling infrastructure. Funding support from the European Union and UK government. A further 20 double deck buses are planned for later in 2020 as part of the JIVE project, at a cost of 10.9 million GBP, plus refuelling infrastructure for around 1.1 million GBP.
Operating Model	Regulated franchise model, with vast majority of network planned and tendered by the transport authority (TfL) and operated by private operators on a cost basis.
Ownership Model	Owned by the transport authority (TfL)
Outcomes	— Ongoing investment in fuel cell buses. — More than 215,000 hours of service. — More than 2.0 million km operated. — Range of 250-300km demonstrated, 16-18 hours per day.

Case Studies cont.

Reading, United Kingdom – Case Study 5

Key aspects

- Bio Gas
- Operator Ownership

Location	Reading, UK
Summary	 Reading Buses is a municipally-owned operator based in Reading, UK. Since 2013, Reading Buses has invested in several tranches of CNG buses. The operator has partnered with the Gas Bus Alliance to offset their gas use with biomethane i.e. biomethane is not used in the buses directly, but natural gas used from the main supply is balanced by injection of biomethane into the grid.
Investment	58 biogas buses and supporting depot refuelling infrastructure. Funded by the operator with supporting central government grants to cover premium.
Operating Model	Deregulated model, with majority of network planned and operated by operators on a commercial for profit basis. Socially necessary but non-commercial routes are planned and tendered by local government on either a cost or subsidy basis.
Ownership Model	Biogas buses are fully owned and maintained by the operator.
Outcomes	— Ongoing investment in biogas buses in Reading. — Operator reports high levels of reliability. — Carbon emissions reduced by up to 84%. — Nitrogen oxide emissions reduced by 55%.

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Next Steps

Next Steps

This report provides an initial view of the options available to Central Government to meet its ambition of a Zero Carbon urban bus fleet within 20 years. There are significant implications for Regional Councils, Auckland Transport and bus operators, therefore we support the Ministry's intention to engage with these parties as a next step.

Potential areas for engagement, include:

- What lessons have been learnt from the New Zealand pilots of Zero Carbon Bus Technology to date?
- What are the current plans in each region to transition to Zero Carbon Bus Technology?
- Are there other options for transitioning the bus fleet that have not been considered in this report?
- What are your preferences for technology, procurement, ownership, timing of transition, funding & financing, and why?

The Ministry may also wish to consider the following:

- Further research on the cost of purchasing new bus fleets, including engaging with bus manufacturers, New Zealand councils that have piloted Zero Carbon buses, and other governments overseas.
- Further research on the age of bus fleets across New Zealand. This may be possible to extract from the PTOM Evaluation data when it is received.
- Further assessment of the funding and financing options, including testing the market appetite for options presented in this report.
- Engaging with Councils and operators on the location of existing depots and appropriateness for a world with Zero Carbon Technology e.g. proximity to power sources, route efficiency, opportunities for development.

G

Appendices

Appendix 1 - Resilient Network Example