greater WELLINGTON
REGIONAL COUNCIL
Te Pane Matua Taiao

COMMERCIAL IN CONFIDENCE

Strategic assessment for transitioning to a zero emission bus fleet 2019

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Executive Summary

1. Introduction and purpose

The Greater Wellington Regional Council (GWRC) has a stated ambition to be the first region in New Zealand to have an all-electric bus fleet.[1]

This paper is a strategic assessment of the motive power options for the Metlink bus fleet and the options for transitioning to an all-electric bus fleet using known technology in battery electric buses. For context, alternative technologies in zero emission buses, such as hydrogen fuel cells, are described in this paper however the assessment does not go into the tactical deployment of electric buses by recommending specific technologies. Nor does it consider specific route by route deployments.

Assessment of alternative technology options and the tactical electrification of specific routes are longer term considerations that can only be evaluated once a transition pathway has been agreed.

2. Background

Fleet improvements are a key element in reducing journey times, increasing service reliability, improving passenger amenity, and contributing to increasing patronage. Fleet improvements are also important in GWRC's strategies for improving operating efficiency and environmental outcomes across the region, particularly in relation to climate change and local air quality. While an effective and attractive public transport is an important enabler to reduce greenhouse gas (GHG) emissions by reducing individual car use, so too is the choice of fleet in delivering public transport.

GWRC is in the midst of a modernisation of its bus fleet to deliver Wellington Region bus services. Due to the cost of maintenance and constraints on operational efficiencies, the trolley buses were retired in October 2017 and the oldest diesel vehicles were replaced by modern low emission diesel buses and a small number of electric buses as part of the new bus contracting regime implemented in mid-2018 as part of changes enabled by the Public Transport Operating Model (PTOM).

Until mid-2018, the Wellington region has been characterised by a relatively old bus fleet, made up of refurbished electric trolley buses and many aging diesel buses. The tendering regime for new bus operating contracts enabled by PTOM provided GWRC with the opportunity to replace at least 50% of the region's oldest buses with newer modern buses that are delivering improvements in both environmental and customer experience outcomes.

[1] For the purposes of this strategic assessment, the terms 'all electric' and 'zero emissions' are used interchangeably. Zero emission vehicles refers to vehicles that emit zero tailpipe greenhouse gas and other harmful emissions. 'All electric' and 'battery electric' buses are a subset of zero emission buses. Other zero emission buses include electric buses that use supercapacitors, rather than batteries, and hydrogen fuel cell buses.

In addition to the retirement of the trolley buses, pre-Euro III diesel buses were required to be retired at the time of PTOM commencement. The improvements in emissions of harmful pollutants from later Euro standard buses meant that significant environmental benefits were realised from upgrading the older diesel buses in the fleet with new Euro V and Euro VI diesel buses.

Modelling undertaken by GWRC prior to the 2018 changes indicated that replacing the trolleys and pre-Euro III standard buses with new Euro V buses would result in a 33% decrease in total emissions per kilometre across the Wellington city fleet, including a 74% decrease in particulate matter emissions. While there would be a small increase in GHG emissions by replacing trolley buses with diesel buses in the short term, GHG emissions from public transport represent less than 1% of regional GHG emissions from all sources, and with trolleys performing around 10% of the public transport bus task, changes in the fleet mix resulted in very minor increases to regional GHG emissions.

The stipulation of new fleet in the PTOM tender process included the specification that all buses must comply with standards set by the Government's Requirements for Urban Buses (RUB) and GWRC's Vehicle Quality Standards. The PTOM tender clearly signalled GWRC's preference for lower emission vehicles and ambitions to move to an all-electric bus fleet. GWRC's tender evaluation methodology monetised different emissions outcomes from the different fleet types submitted by different tenderers. These monetised valuations contributed to the final assessments to choose successful operators.

The incentives and signals given for low emission fleets in the tender contributed to the realisation of GWRC's desired outcomes. The two companies that won the tendered contracts (Tranzit and Uzabus) committed to delivering a new, more environmentally friendly bus fleet that will improve air quality across the region. The majority of the buses that have been introduced by Tranzit, Uzabus and Mana (who was directly awarded two contracts) have been new, Euro VI diesel vehicles. The modelled improvement in fleet emissions (Based on the PTOM tender process) was an estimated 38 per cent reduction in harmful pollutants in Wellington city and 84 per cent reduction in the Hutt Valley.

A subsequent agreement with Tranzit has enabled the introduction of 10 electric double-decker buses (EVDD) to Wellington, with a commitment to introduce another 10 in 2020 and a further 12 in 2021. This will represent a further improvement in the region's transport emissions and a significant step towards GWRC's goal of an all-electric bus fleet.

Ongoing fleet renewals and expansion represent ongoing opportunities to further upgrade the region's bus fleet.

GWRC is now investigating options for further improvements to the environmental sustainability of its bus fleet, in particular the reduction in GHG emissions, and how it can transition over time to a deliver on its ultimate ambition of an all-electric bus fleet.

3. Electric bus market developments

Urban air quality and climate change are major issues facing all cities around the world. Replacement of diesel buses with electric buses in public transit fleets is a key tactic in

reducing harmful tailpipe emissions in built up urban areas and reducing CO2 emissions.

While public transport using diesel buses is still substantially more efficient than the alternative of hundreds of private vehicles on the road, diesel buses contribution to GHG emissions could largely be reduced by utilising electric buses.

Consequently, many governments around the world are investigating measures to reduce GHG emissions from their public transport fleets by investing in alternative powertrains, in particular electric buses. There are now a number of cities around the world implementing fleet electrification targets or ultra-low emission zones.

Bloomberg New Energy Finance estimates 13% of the global fleet of municipal buses are electric buses, with 99% of those located in China. Electric buses currently comprise 4.2% of the UK bus sector, 1.6% in Europe and around 0.5% in the US.[2]

Demand in China has been driven by high levels of subsidy to address stringent air quality targets as a result of China having some of the worst air pollution levels in the world. Major cities like Shanghai and Shenzhen have stopped purchasing diesel buses and are only buying electric.

Thirteen cities have signed the C40 Fossil Fuel Free Streets Declaration, including Auckland, alongside Paris, Los Angeles, London and Vancouver amongst others. The principal commitments of the C40 Declaration is to procure only zero-emission buses from 2025 and ensure that the major area of each city is zero emission by 2030. Many signatory cities have targets that exceed the ambition of the declaration. Paris aims to electrify all of its 4,500 buses by 2025, Copenhagen has committed to procure only zero-emission buses from 2019, and Los Angeles has the same target for its fleet of 2,200 buses by 2030.

By mid-2019 London will have a fleet of 240 battery electric buses and ten hydrogen buses out of a fleet of 9,400 buses, around 2.6%. Twenty hydrogen double deck buses will be added to the fleet form 2020. London also has a fleet of 3,240 hybrid buses. London's target for all buses to be zero emission is 2037.

Auckland has recently released its low emission bus pathway, which recommends that, other than ongoing trials of electric and hydrogen buses, electric buses will only be added to the Auckland fleet from 2025 for end-of-life bus replacements and fleet growth. On current trajectories Auckland Transport expect to have a zero emission bus fleet by 2040.

4. Technology developments

The premium on the purchase price of e-buses is heavily influenced by the cost of batteries, with batteries attributing as much as 50% of a vehicle's overall cost at present. However, as a result of ongoing increases in manufacturing capacity and technology improvements, this cost is expected to continue to fall consistent with falling costs over the last few years. Research undertaken by Bloomberg New Energy Finance (BNEF)

[2] Bloomberg New Energy Finance, Electric buses in Cities, 2018

show that the price for battery packs overall has fallen by 24% since 2016 and 79% since 2010.[3]

It is expected that the price curve for battery electric buses will be most heavily influenced by the continued fall in battery prices. Based on the trajectory of battery prices, BNEF estimates price parity of electric buses with diesel buses by around 2030.

5. Electrical infrastructure

A significant factor (and cost) associated with the transition to an all-electric bus fleet is the ability of the existing electrical transmission and distribution network to supply electricity to the charging infrastructure that would be required to charge Wellington's bus fleet.

To better understand the electrical network supply issues and the associated costs, GWRC commissioned engineering consultancy Jacobs New Zealand Limited (Jacobs) to undertake an investigative study of Greater Wellington region's electrical infrastructure to support the charging of e-buses.

Overall, compared to the expected costs of the electric buses themselves (in the order of $500k to $1m per e-bus) and the charging infrastructure at the depots, the network connection costs to accommodate e-bus charging in the Wellington region appear to be relatively modest, in the order of $100,000 to $200,000 per depot.

The biggest challenge will be in the design of the internal depot charging infrastructure given the spatial limitations at some of the sites and the assumption that the bus depots would use smart charge management to control bus charging speeds and time of day charging to avoid peak loading and significant electricity network upgrade costs.

6. Transition options

It can be concluded that with the imperative to reduce greenhouse gases from transport emissions, coupled with advances in electric vehicle technology and New Zealand's high levels of renewably generated electricity, GWRC will transition to an all electric bus fleet over time. The question, and therefore the options in relation to transition, is about timing and how rapidly the transition may occur.

All transition options are feasible but come with a price tag. It is important to consider the overarching benefits of an efficient and effective public transport network in reducing car use, and therefore the cost and benefits of transitioning to an electric bus fleet must be weighed up against investments in other aspects of the PT network that will grow patronage and reduce GHG emissions from car use.

The transition options evaluated for the purposes of this strategic assessment cover two different scenarios for the rate of transition. These scenarios are:

6.1 'Organic' – Assumes the phased implementation of 51 electric buses by NZ Bus from 2020, with 18 interim diesel buses retained and upgraded to an existing bus standard. Electric buses then only procured from 2021 to meet

[3] Bloomberg New Energy Finance, Electric buses in Cities, 2018

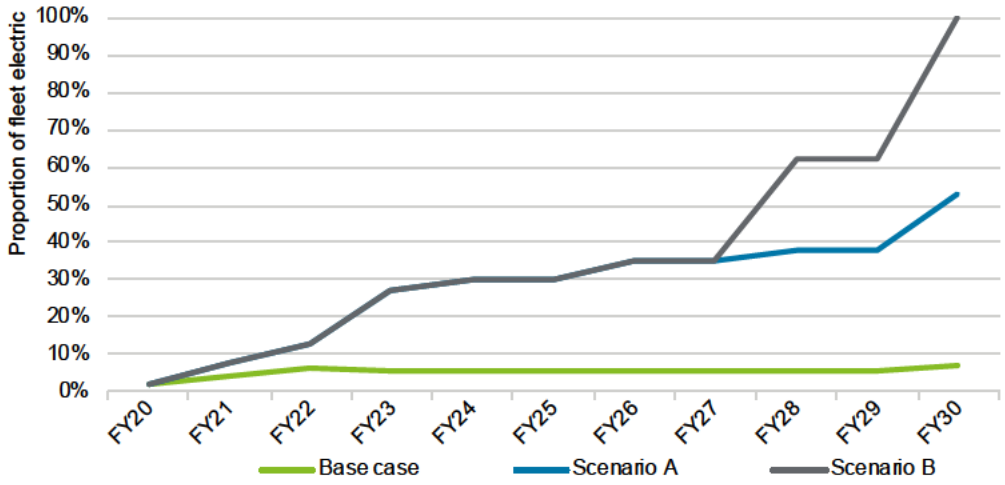
growth needs and to replace age expiring buses, i.e. as existing buses reach 20 years of age.

6.2 'Step Change 2027' – As for Scenario A but electric buses only are specified in all future bus contracts from 2027, i.e. at the re-tendering of the current PTOM bus contracts at end of term in 2027 and 2030.

Each transition option has been compared against a base case of continued investment in diesel buses.

Both scenarios and the base case assume the commencement of a mass transit solution in Wellington city in 2030, at which time the bus fleet in Wellington city reduces by approximately 160 buses.[4]

Electric bus fleet profile by scenario



Modelling of the scenarios considered the following primary costs and benefits:

- Capital and finance charges for electric buses compared against diesel buses
- Operating cost savings compared against diesel buses
- Electrical infrastructure upgrades necessary to support large scale electric bus charging at depots and termini.
- Emission reduction benefits – measured by monetising reductions in CO_2 and four harmful tailpipe pollutants[5].

7. Emissions benefits

Emissions modelling has been undertaken to 2030 and as expected, all transition scenarios demonstrate significant reduction benefits across all pollutants when compared with the diesel Base Case.[6]

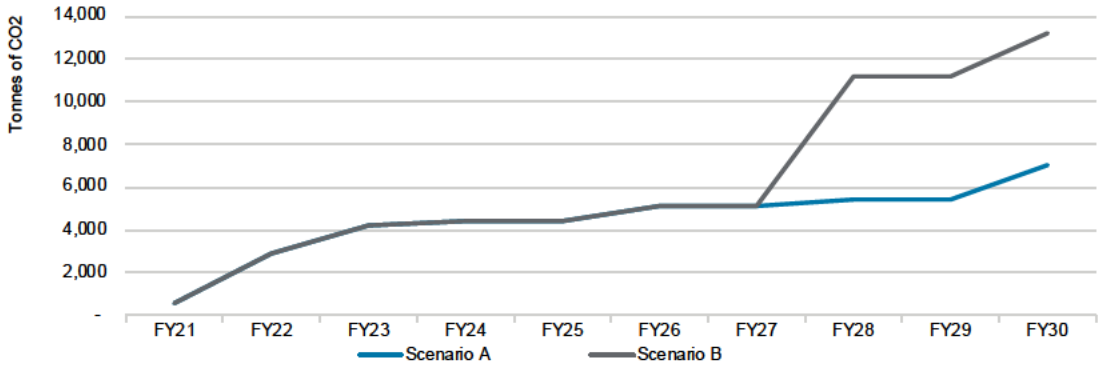
[4] Ian Wallis & Associates, LGWM rapid transit network options final draft, 2018

[5] Emission reduction benefits were modelled using the same methodology that was developed to calculate the Emissions Improvement Premium in the PTOM bus tender process.

Estimated emissions impact

Pollutant	FY21	FY30		
	Base Case Tonnes	Base Case Tonnes	Scenario A Reduction relative to Base Case	Scenario B
CO_2	16,863	16,450	*48%*	*92%*
PM_{10}	0.7	0.3	*67%*	*89%*
NO_x	53	32	*72%*	*89%*
CO	17	12	*68%*	*89%*
HC	1.7	0.8	*52%*	*91%*
Est. cost (pa)	**$2.3m**	**$1.8m**	***57%***	***91%***

Annual reduction in CO_2 compared to Base Case (tonnes)



8. Financial modelling outcomes

Both transition scenarios are more expensive than the Base Case, indicating that the still relatively high capital costs for electric buses and associated infrastructure are not yet offset by operating cost and emission reduction savings over the 11 year modelling period.

The estimated total cost increase over the period from 2019 to 2030 relative to the Base Case is summarised as:

- Scenario A $29.6m total additional cost; $19.4m Net Present Cost
- Scenario B $43.4m total additional cost; $27.2m NPC

[6] For monetizing the effects of emissions reduction, the same values for each pollutant have been used as published in 'Evaluating Bus Emissions: What colour, how big and how much is that elephant in the window?' by Kuschel and Cooper. For CO_2 a value of NZ$65.99 (in 2015 dollars) has been used.

Total cost comparison (2019 – 2030)

$m (undiscounted)	Base Case	Scenario A	Scenario B
Operating costs			
Energy costs (diesel/electricity), RUC	118.7	103.1	97.0
RUC[7]	70.9	65.7	67.6
Total operating costs	189.6	168.8	164.6
Capital costs			
Bus capital payments[8]	261.7	318.6	338.4
Electricity infrastructure costs	-	1.9	2.0
Total capital costs	261.7	318.6	338.4
Net cash flows	**451.2**	**487.4**	**503.0**
Economic cost of emissions	23.3	16.8	15.0
Net cost (including emissions)	**474.6**	**504.2**	**517.9**
Variance		29.6	43.4
Variance (Net Present Cost)		*19.4*	*27.2*
Fleet numbers as at July 2030[9]			
- Diesel buses	403	311	0
- Electric buses	32	230	435
Total fleet	**435**	**435**	**435**
Proportion of fleet electric	7.4%	42.5%	100%

A number of simplifying assumptions were used for modelling purposes. These include:

7(2)(i)

a) [redacted].

b) For Scenario B, all remaining diesel fleet is replaced as PTOM contracts expire and are retendered – for contracts outside Wellington city this is assumed to occur in 2027 at the current expiry time, and all Wellington city contracts are assumed to be extended until 2030 to coincide with the opening of the future mass transit system.

c) The diesel fleet is replaced in 2027 and 2030 by new electric buses, however a lower cost alternative scenario may be the conversion of diesel buses to electric buses.

d) RUC is reinstated in December 2025 at existing diesel rates – RUC reinstatement on electric vehicles may be at lower rates.

9. A possible Wellington zero emission bus pathway

Scenario A will achieve a zero emission bus fleet for the Greater Wellington region by 2040, whereas a transition pathway as reflected by Scenario B would see a zero emission bus fleet for the region by 2030.

[7] The lower than expected benefit from RUC, particularly in Scenario B, is due to reinstatement of RUC in Dec 2025 after which time the majority of bus replacements are made, and a simplifying assumption for modelling purposes that all electric bus replacements are large vehicles which incur higher RUC rates than medium and small vehicles.
[8] Bus capital payments includes the cost of the vehicle, batteries and chargers.
[9] Bus fleet assumed to reduce by approximately 160 buses on commencement of a mass transit solution in 2030, from a bus fleet of 598 in 2029.

Both pathway options commence with step changes, namely Tranzit's currently committed remaining 22 EVDD in service by July 2021 and the in-principle agreement with NZ Bus for 51 new electric buses to be phased in by July 2022.

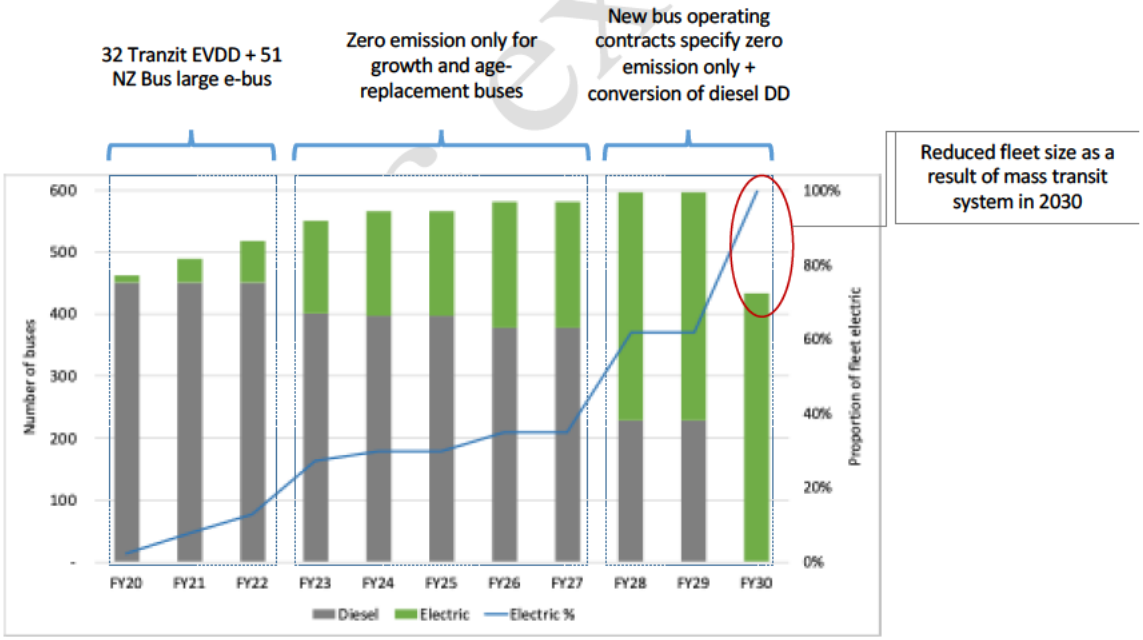
The pathway reflected by Scenario B concludes with a step change between 2027 and 2030, when future bus contracts will specify zero-emission buses only. In the intervening period between now and 2030, operators will be required to procure only zero-emission buses for end-of-life bus replacements and fleet growth.

The exception will be high capacity double decker buses as there is no known battery electric bus options that can deliver to this capacity under New Zealand's currently restrictive axle weight regulations.[10]

To achieve a 100% electric fleet by 2030, it is necessary to assume that options will exist to economically convert current and future diesel double deckers to electric by 2030.

All 'interim' buses that have been introduced since contracts went live in July 2018 to provide additional capacity and service enhancement will be upgraded and refurbished to 'existing' bus standards and retained in the fleet. These buses will be replaced when they reach 20 years of age or when current bus contracts expire between 2027 and 2030, whichever is sooner.

Potential zero emission bus pathway – Scenario B



10. Financial impact

From FY22, additional budget has been allowed in the Long Term Plan 2018-2028 for the future introduction of electric buses. This line item has been included as a "motive power premium" for the express purpose of funding the uptake of zero emission buses.

[10] Tranzit's EV double deckers have a maximum capacity of 82 passengers and are officially classified as a Large Vehicle (LV) and not a double decker (DD) for timetabling purposes.

At the time that the premium was included in the 2018-2028 LTP, 2022 was the expected timing in which suitable electric buses for Wellington conditions would become available.

Report RPE19.188 sought Council approval of the proposal from NZ Bus to seek proposals for the procurement and introduction of 51 new electric buses to replace the trolley fleet. This strategic assessment assumes that that procurement proceeds. Report RPE19.188 noted that additional funding would be required to enable the procurement of the 51 electric buses and that this funding could come from the motive power premium, thereby reducing the funding available for additional electric fleet. This funding is factored into the analysis below.

7(2)(i)

[redacted]

The financial impact of the two scenarios for the period to FY28 against the remaining "motive power premium" in the 2018-2028 LTP budget is shown below.

[redacted]

7(2)(i)

7(2)(i)

7(2)(i)

[redacted]

The financial impact at this time will be contingent on the impacts of the mass transit solution on a) the timing of bus contract replacements and b) the numbers of buses that will form future bus contracts in Wellington city in particular.

11. Key challenges and considerations

11.1 Ability to negotiate an affordable price with bus operators

The principal underlying challenge that may constrain the pace at which GWRC wishes to transition to an all electric bus fleet is the current capital costs of electric buses which are substantially higher than comparable diesel buses. At present, the whole of life costs for electric buses remain higher than diesel buses, though this is changing at a relatively rapid rate. In other jurisdictions around the world electric bus deployments are supported by Government subsidies in various forms, often on the basis of improving air quality in cities.

Compounding the higher capital cost challenge is GWRC's ability to negotiate an affordable price with its bus operators. This challenge is exacerbated given the risk of

ownership associated with new technology and the relatively short contract tenure of current bus contracts – potentially only 7 years remaining on most PTOM contracts by the time the first new e-buses will be in service. Any requirement by GWRC for operators to purchase and operate electric buses will necessitate the negotiation of a contract variation.

Due to the short contract tenure remaining in the PTOM contracts relative to the asset life of electric buses, it is proposed that, with the exception of the 32 committed EVDD, all electric buses (and charging units) procured by operators under the PTOM contracts be transferring assets to GWRC at end of the contract terms.

[redacted]

7(2)(i)

[redacted]

11.3 Fleet utilisation risks

Range constraints of electric buses present a further challenge that adds risk to operators. If the addition of electric buses compromises the efficient utilisation of fleet by an operator due to the need to specifically manage the duties performed by electric buses, the operator may need additional buses in their fleet to make up for the loss in utilisation – adding further cost to the electric bus transition.

11.4 GWRC capability

Transitioning bus fleets to a new technology, while phasing out others, represents a substantial change and undertaking for both operators and GWRC.

Managing the commercial negotiations to implement bus technology changes and protecting GWRC's long term interests in fleet investment decisions and maintenance will require GWRC to engage and retain, either on contract or inhouse, specific

technical and commercial capability to ensure GWRC's long term interests are protected.

12. Conclusion

Due to the significant annual incremental cost from FY28 of specifying zero emission buses only in all future bus contracts, Council may wish to commit to an official zero emission bus fleet target of 2037. Such a target is consistent with many international cities and ahead of Auckland's current target of 2040. Council is then able to retain the flexibility to advance the target at any time in the future, dependent on considerations such as the evolution of future technologies, the impacts of a mass transit solution in Wellington city and the nature of future bus contracts from 2027.

13. Next steps

Council endorsement of the pathway to a zero emission bus fleet as proposed in this paper will inform the fleet related priorities, policies and actions in the future PT Plan review process. This will enable the community and key stakeholders to be consulted on Council's preferred transition pathway.