Better bus fleets for New Zealand

Evaluating costs and trade-offs

by Peter Nunns, Jenson Varghese and Saeid Adli
MRCagney, Consultants in Planning and Transportation

MRC

KEY FINDINGS

Transport agencies are increasingly aware that emerging vehicle technologies will pose new opportunities and challenges for transport investment and public transport provision. Transport agencies face several challenges when deciding when and how to respond to emerging technologies.

- First, these technologies are not yet market ready, and there is uncertainty about when they will be widely deployed. It is important to have a strategy for responding when new technologies become widely available, without committing in advance to adopting unproven technology.
- Second, it is often necessary to balance value for money (cost-effectiveness) with economic and environmental benefits. New vehicle technologies may be more expensive in terms of up-front purchase costs while offering long-term operating cost savings or broader benefits.

This paper presents an approach to modelling and quantifying the long-term effects of alternative fuel technologies on purchase and operating costs and environmental outcomes related to vehicle operation. While it applies this approach to the case of urban bus fleets in particular, this approach can in principle be extended to the broader vehicle fleet. It can be used to support policy and investment decisions related to the deployment of new vehicle technologies.

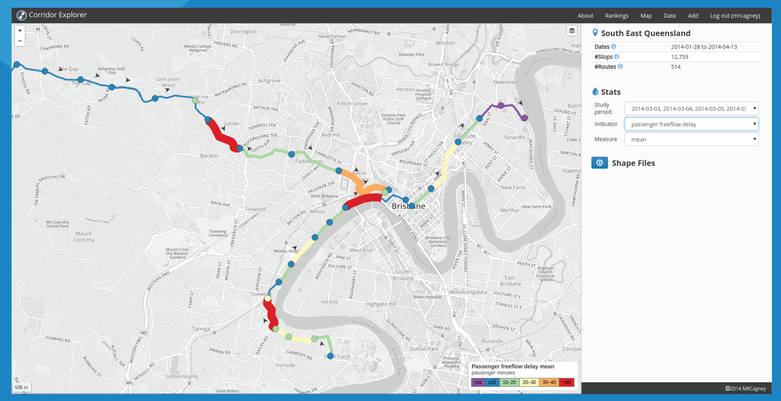
MODEL APPROACH

The modelling approach in this report is based on work undertaken by the authors for several regional transport agencies in New Zealand as well as the Energy Efficiency and Conservation Authority. Some results have previously been published in various formats.

We use data on the composition and age of existing urban bus fleets to develop high-level scenarios for progressively upgrading the fleet with new vehicle technologies. Importantly, these scenarios do not envisage replacing the existing fleet en masse – instead, they assume that new buses will be added to the fleet incrementally when needed to replace old buses leaving service. In addition, our approach can be used to consider the impact of policy changes and contract timing. For example, transport agencies or bus operators may use the implementation of new contracts as an opportunity to renew their fleets.

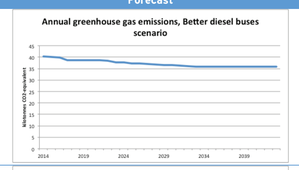
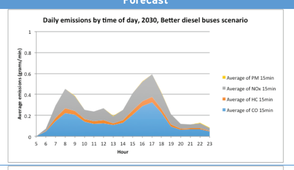
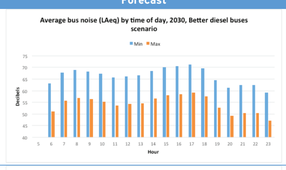
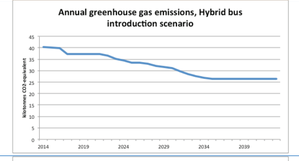
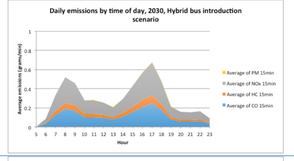
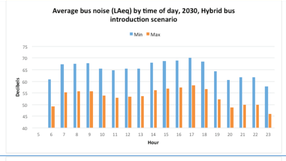
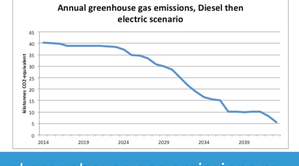
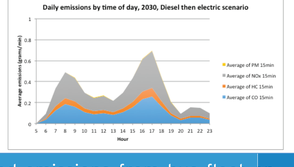
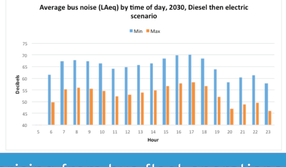
Future fleet composition scenario definition

Scenario Name	Definition	Notes
Better diesel buses	Buses exiting the fleet are replaced by the most advanced standard for diesel buses –Euro 6 buses	This scenario reflects the most modest fleet upgrade path available
Hybrid bus introduction	Buses exiting the fleet are replaced by hybrid buses starting 2017	This scenario would allow for earlier introduction of new bus technologies
Diesel then electric	Buses entering the fleet before 2024 are replaced by Euro 5 diesel buses; starting in 2024 they will be replaced by electric buses	This scenario would move towards electric buses when they are market-ready and use diesel buses as a bridging measure



We developed a model of whole-of-life fleet outcomes, including bus purchase and operating costs and vehicle noise and emissions, that can be used to test the impact of alternative bus procurement policies. Our model is based on Generalised Transit Feed Specification (GTFS) data and geographic information system (GIS) analysis in conjunction with flexible spreadsheet-based scenario modelling and Python scripting.

Our approach is flexible and can be readily adapted for analysis of individual transport agencies' fleet challenges. Because 871 transit agencies all around the world are currently using GTFS, we are able to access data on bus flows throughout the network for most cities. The maps above illustrate the spatial GTFS analysis capability available through MRCagney's transitflow.net service.

	GREEN HOUSE EMISSIONS		LOCALISED EMISSIONS		NOISE	
	Comments	Forecast	Comments	Forecast	Comments	Forecast
BETTER DIESEL BUSES	Upgrading the fleet with Euro 6 buses would result in incremental reductions in greenhouse gas emissions as a result of slight improvements in fuel economy.		Upgrading the fleet to Euro 6 standard would result in a lower path for localised emissions in the short term. Our analysis suggests that peaks in emissions will closely follow peaks in vehicle movements. Emissions are higher in the afternoon and evening peak, which is a significant concern given the fact that pedestrian movements in the area are also likely to be higher during this time.		Introducing Euro 6 buses is expected to bring few reductions in noise relative to the current fleet as diesel buses tend to be comparably noisy. As this graph shows, noise levels vary throughout the day, with the highest noise levels reported in the afternoon and evening peak. The wide range between minimum and maximum sound levels provides an indication of the range of outcomes experienced on the street at a point in time depending upon bus speed change cycles.	
HYBRID BUS INTRODUCTION	Transitioning the fleet to hybrid buses beginning in 2017 would result in significant reductions in greenhouse gas emissions – emissions would ultimately fall by one-third. However, the ongoing use of diesel fuel would make further reductions in emissions unlikely. This would support plans to reduce greenhouse gas emissions from transport while not fully decarbonising the bus fleet.		Interestingly, upgrading the fleet to hybrid buses will not necessarily lower aggregate emissions relative to a Euro 6 upgrade path. However, as this graph shows, carbon monoxide emissions are expected to be significantly lower under this scenario. This analysis does not consider the fact that parallel hybrids could be run under battery power in the city centre – which could result in considerably better environmental performance in this area.		Introducing hybrid buses is expected to result in an average one decibel reduction in bus noise relative to the Do-Minimum scenario. This reduction appears to be slightly greater during the AM peak period and midday period, with slightly smaller reductions in the afternoon and evening peak. Once again, this analysis does not factor in the option for parallel hybrids to run on battery power in the city centre, which would result in further noise reductions.	
DIESEL THEN ELECTRIC	Transitioning the fleet to electric buses beginning in the mid-2020s would result in relatively few emissions reductions in the short term, but over the longer term emissions would fall dramatically. By 2041, emissions would have fallen by three-quarters. This scenario would align best with New Zealand's plans to reduce greenhouse gas emissions. Even a more conservative approach to introducing electric buses will still result in long-term benefits.		Upgrading the fleet to electric buses would deliver slower reductions in emissions by 2030, due to the fact that electric bus introduction would only begin in 2024. However, this graph shows that by 2030, the electric bus upgrade path would roughly match outcomes from the hybrid bus scenario. Over the longer term, gains are expected to be significantly greater.		Introducing electric buses starting in 2024 is expected to reduce average bus noise by approximately one decibel relative to the Do-Minimum scenario. Noise reductions are likely to be greater in the AM peak and midday period, and in the evening. Reductions in bus noise after 2030 are likely to be even significant as more relatively quiet electric buses enter the fleet. By 2041, bus noise is expected to be five to seven decibels lower than it would be under the Do-Minimum scenario.	

We have modelled annual greenhouse gas emissions resulting from bus fleet operations over the next 40 years using information on current bus service-kilometres, estimated fuel economy of alternative bus types, and MBIE's forecasts for the future share of renewable electricity generation. These forecasts assume that the total service-kilometres operated will remain constant over time.

We have modelled localised emissions from bus fleet operations along a single corridor in the city centre. In order to do so, we have used Generalised Transit Feed Specification Generalised Transit Feed Specification (GTFS) data on urban bus fleets, which allows us to identify the timing and location of bus movements during a typical weekday, in conjunction with data on the expected emissions from different types of buses.

We have modelled noise arising from bus fleet operations along a major city centre bus corridor. In order to do so, we have used Generalised Transit Feed Specification Generalised Transit Feed Specification (GTFS) data, which allows us to identify the timing and location of bus movements during a typical weekday, in conjunction with data on noise from different types of buses .