NZTA research summary

April 2024

Zero-emission bus economics study

An Excel model, created in research by Castalia, will allow users to evaluate the costs and benefits of replacing existing diesel buses with zero or low-emission bus options.

Designed to enable Waka Kotahi and public transport authorities to make informed decarbonisation decisions, the model incorporates 10 different bus options, operating on numerous different types of bus routes.

The model calculates and compares the costs of each option and enables users to customise its assumptions and inputs to better reflect the environment their buses operate in.

Named 'the ZEB Cost Model', it includes options for:

- retiring and replacing diesel buses with ZEB right away
- replacing diesel buses with ZEB on their normal routes, then retaining the diesel buses to expand public transport options, in order to encourage more people to use public transport
- waiting until the end of a diesel bus's useful life and then replacing it
- maintaining business as usual, with authorities continuing to buy and use new diesel buses.

The various zero- or low-emission bus technologies incorporated include battery electric buses and hydrogen-fuel-cell buses, which could replace or complement existing diesel buses at various stages of their life. There are also options for continuing to use existing diesel buses but decreasing their emissions through replacing diesel fuel with 100% renewable diesel, blending hydrogen with the diesel, or fully converting them to battery electric buses.

What the model tells us

The model calculates the total cost of ownership (TCO) and marginal abatement cost (MAC) for each of the 10 bus technology options on three different route types: urban, suburban and rural. Routes can be further adjusted based on their speed and terrain.

TCO represents the total cost to own and operate each type of bus on a per kilometre basis. It takes into account all costs associated with the bus over its entire lifespan, including capital expenditure costs, fuel or energy costs, operational expenditure costs (including maintenance), financing costs, residual value and emissions.

MAC, on the other hand, evaluates how cost-effective the different bus technologies are in reducing greenhouse gas emissions. It measures the cost of reducing or avoiding one unit of emissions, compared to a baseline scenario, and enables different technologies to be compared.

By providing both the TCO and the MAC, the model helps users compare the different bus technologies, based on their capital, operating and external costs, including greenhouse gas and other harmful emissions on routes customised to reflect the ones where they are considering replacing a diesel bus.

Inputs are customised on the model's 'Dashboard', with adjustments able to be made to bus and route characteristics. Further, the model includes a built-in sensitivity analysis function which allows users to assess how increases or decreases in key cost drivers (for example, the cost of diesel) impact the overall TCO analysis. Finally, users can further customise the model by adjusting, for example, assumptions for bus capital and operational expenditures to match the specific investments they may be considering.

Findings from the research

While the model does not provide one definitive answer on the best ZEB technology for all PTAs, several key findings of interest emerged in the process of making and testing the model. These included that:

- the emissions saved by retiring diesel buses early far outweigh the emissions generated by constructing replacement ZEB
- operations and maintenance costs, particularly energy costs, are the main factor affecting the TCO for different bus technologies – any minor variations in capital expenditure, arising from the adoption of alternative technologies are unlikely to have a substantial effect on TCO
- battery electric buses are the lowest cost option for replacing existing diesel buses. This is because of the high cost of hydrogen in New Zealand at the time of the research and the importance of fuel costs in overall TCO.

Improving the data

Data collection was an important aspect of the research, with comprehensive information gathered about the costs, emissions and other aspects of the bus technologies included in the model.

However, much of the available data – especially that sourced from reports and other sources – drew from the US, Europe or Australia. Although this was complemented by interviews with industry professionals and experts in New Zealand, the lack of comprehensive data and information was identified as a limitation in the research.

To address this, it was proposed that opportunities for collaboration and data sharing among stakeholders, including public transport authorities, bus operators and manufacturers, and research institutions, should be explored. By pooling resources and data, and using consistent data collection standards, researchers can build a more comprehensive database.

This would enhance the model's usefulness, enabling more accurate assessments to be made of the cost and emission reduction potential of the various bus technologies, and contributing to the successful and sustainable decarbonisation of public transport in New Zealand.

RR 718: Zero-emission bus economics study. NZ Transport Agency Waka Kotahi research report. Available at **www.nzta.govt.nz/resources/research/reports/718**