Title

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Author
Samuelsen, Scott

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Electrified Buses Provide Life Cycle Environmental Benefits but Need Cost Reductions and Policy Support for Near-Term Adoption

Scott Samuelsen
Advanced Power and Energy Program, University of California Irvine

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Issue

In December 2018, the California Air Resources Board (CARB) approved the Innovative Clean Transit regulation, which is designed to transition the state to all-electric bus fleets by 2040. To comply with this first-of its-kind regulation, transit agencies have two alternatives: battery electric buses (BEBs) and hydrogen fuel cell electric buses (FCEBs). These options vary in energy requirements, overall effectiveness in reducing different emission types, associated life cycle costs (including disposal of the bus), and ability to meet operating needs of transit agencies.

To support transit agencies and decision makers transition to cleaner bus technologies, researchers at UC Irvine developed a life cycle-based analysis (LCA) tool to estimate the potential costs and benefits of switching to BEBs and FCEBs compared to conventional buses. The LCA tool was tested on the Orange County Transportation Authority (OCTA) to better understand the environmental impacts and cost constraints.

Key Research Findings

Both FCEBs and long-range BEBs (that don't require recharging on route) provide significant environmental benefits compared to conventional buses. When renewable energy is used for electric charging or hydrogen production, the reduction in environmental footprint for FCEBs and BEBs compared to diesel and compressed natural gas (CNG) buses is similar. However, when non-renewable resources are used, BEBs provide slightly larger benefits due to the higher efficiency of their fuel supply chain.

FCEBs and BEBs have comparable total costs of ownership but both have slightly higher costs compared to diesel and natural gas buses. Using the Orange County Transportation Authority as a test case, the life-cycle costs of OCTA BEBs and FCEBs is $2.84 million and $2.89 million, per bus, respectively, compared to natural gas buses ($2.46 million), and diesel buses ($2.55 million). See Figure 1. BEBs benefit from increased efficiency and lower purchase costs compared to FCEBs, but incur additional costs due to the need to install high power charging infrastructure, and to replace the batteries during the midlife stage of these buses. Additional BEBs may also be needed to cover the same distances as some current bus routes. FCEBs have minimal midlife replacement costs and relatively lower fueling infrastructure costs, but incur higher fuel costs and initial purchase prices. Switching to electrified bus technology will cost transit agencies 15-17% more per bus compared to natural gas buses and 11-13% more than diesel buses.

The cost of BEBs and FCEBs are expected to decrease in the future due to decreasing renewable energy costs and economies of scale. Initial purchase prices and fuel costs for BEBs and FCEBs account for most of their higher cost compared to conventional vehicles. However, as more BEBs and FCEBs are produced costs should come down. Additionally, the falling costs of renewable energy resources should contribute to decreased fuel costs for these electrified alternatives.

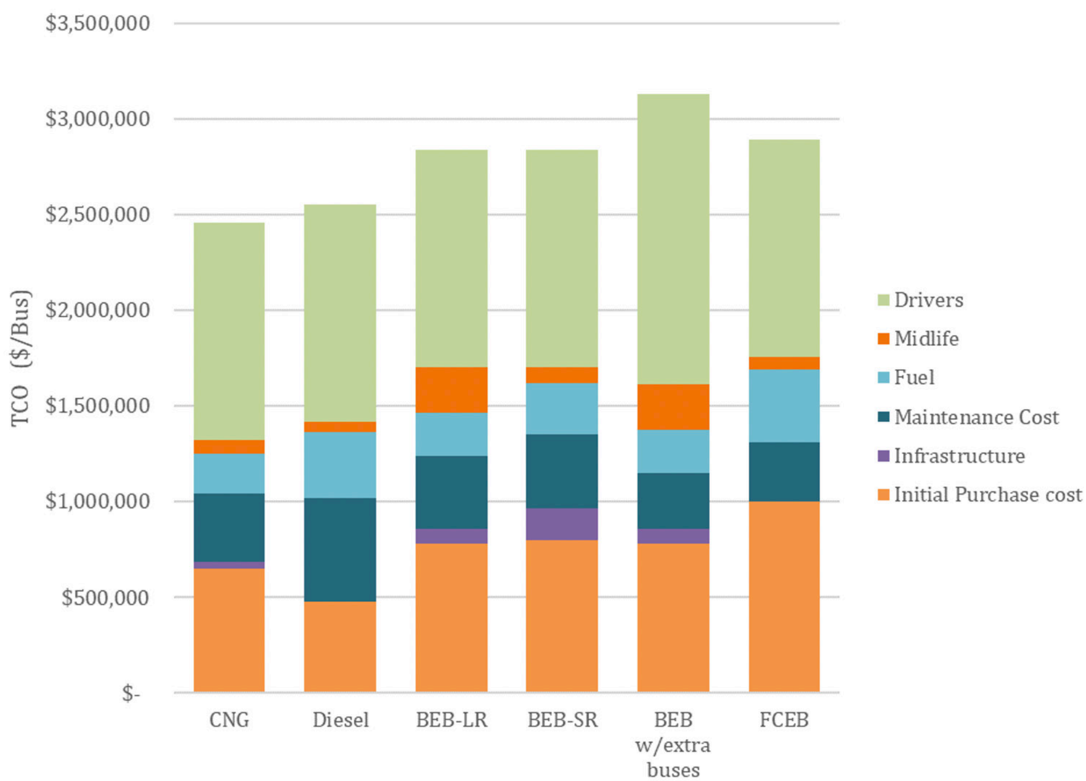

Figure 1. Total cost of ownership of zero-emission and conventional-fuel buses

Policies to reduce the initial purchase cost and supplement the cost of electricity are needed for transit agencies to adopt BEBs and FCEBs in the near-term. These policies could include tax credits or subsidies for the purchase of an FCEB or BEB by a transit agency, similar to the incentives currently in place for light-duty zero emission vehicles, and subsidized or discounted electricity rates for BEB charging or FCEB fuel production.

More Information

This policy brief is drawn from the final project report entitled "Life Cycle Assessment of Environmental and Economic Impacts of Deploying Alternative Urban Bus Powertrain Technologies in the South Coast Air Basin" written by Analy Castillo Munoz, Brian Tarroja, and Scott Samuelsen at the University of California Irvine. The report is available at: www.ucits.org/research-project/2018-24. For more information, please contact Professor Samuelsen at gss@apep.uci.edu.

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