Life Cycle Environmental Impact of Houston METRO System – Evaluation of Electric Alternatives

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Assessing the life cycle emissions and life cycle cost of diesel buses, diesel hybrid buses, and electric bus operated by Houston METRO

The Houston METRO system is a key element in Houston's infrastructure that can be expanded to lower emissions of criteria air pollutants (CAPs) and greenhouse gases (GHGs) and improve regional air quality. Our study's objective is to develop environmental life cycle assessment and cost analysis for conventional diesel buses, diesel hybrid buses, and alternative electric buses operated by Houston METRO using the GREET model. The life cycle GHG emissions of electric buses are slightly lower than the other two types of buses in Houston. However, all the other major emissions such as CO, NOx, PM_{10}, $PM_{2.5}$, VOCs, SO_x, N_2O, CH_4, black carbon, and primary organic carbon associated with electric buses are higher than those for diesel buses. Thus, the overall life cycle environmental cost of electric buses seems to be higher than diesel buses. The life cycle costs of buses are very sensitive to future diesel and electricity prices.

Background

The Greater Houston area comprising 9 counties has a population of 6.9 million and is served by the Metropolitan Transit Authority of Harris County (METRO). As per EPA's 2014 National Emission Inventory, mobile sources (on- and off-road vehicles) contributed to the highest share (67%) of nitrogen oxide (NOx) emissions and second-highest share (23%) of volatile organic carbon (VOC) emissions in the Houston-Galveston-Brazoria (HGB) Area. The METRO system is a critical element in Houston's infrastructure that can be expanded to lower emissions of CAPs and GHGs, and improve regional air quality.

Currently, there is a lack of quality data on the comprehensive energy and environmental impacts of the METRO system by comparing life cycle emissions and the cost of conventional diesel buses, diesel hybrid buses, and electric buses.

Project Summary

The overall goal of this study is to provide an estimate of the energy and environmental impacts from the total life cycle of the Houston METRO system and provide a cost-benefit analysis for an electrification alternative. Specific objectives are to (1) estimate the total GHG and CAP emissions from the current operational routes of the diesel buses of the Houston METRO system; (2) quantify the total energy and environmental impact resulting from Houston METRO; (3) evaluate the net change in energy, environmental impact, and cost due to transitioning of the METRO fleet to electric buses. These objectives will be accomplished by evaluating life cycle emissions of conventional diesel buses, diesel hybrid buses, and electric buses in Houston with GREET 2019 and estimating the life cycle cost and environmental cost of these vehicles.

Status Update

The initial life cycle inventories of low-sulfur diesel and electric transit bus operations were built from the GREET 2019 model. The electric bus model was determined as the BYD K9 40' electric transit bus. With respect to life cycle GHG emissions in 2020, there is a slightly lower for electric buses than conventional diesel buses, but higher than diesel hybrid buses in Houston (Figure 1a). All the other major emissions such as CO, NOx, PM10, PM2.5, VOCs, SOx, and N_2O, methane, black carbon, and primary carbon associated with electric buses are higher than both types of diesel buses (Figure 1b).

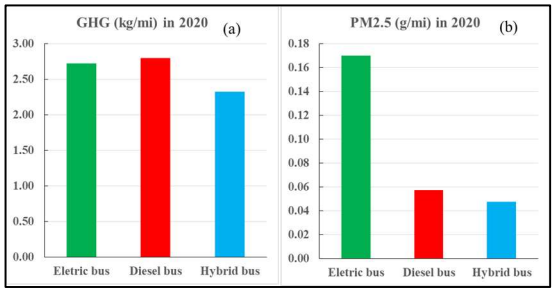

Figure 1. Life cycle emissions of GHGs and PM2.5 associated with electric buses, diesel buses, and diesel hybrid buses in Houston in 2020.

Compared to the emissions in 2020, all the emissions in 2040 would keep similar trends. Life

cycle cost analyses of electric buses, conventional diesel buses, and diesel hybrid buses used in Houston were conducted by Integrating with LCA. At the end of the 24th year, the electric bus system has the lowest costs with an entire life cycle cost of US$714.2 million (Figure 2). The environmental cost analysis demonstrates that conventional diesel buses and diesel hybrid buses can save more than electric buses in Houston.

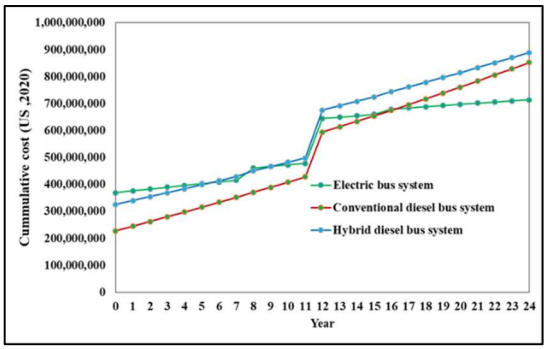

Figure 2. Cumulative costs of plug-in electric, conventional diesel, and diesel hybrid bus systems.

Impacts

The main benefits of this study are: (a) compare life cycle environmental impact and economic analysis for electric buses, diesel buses, and diesel hybrid buses in the Greater Houston area, (b) enhance training opportunity for students in the region, and (c) provide guidance to stakeholders, community leaders within Houston on the adoption of electric vehicles, and the expansion of METRO ridership. The deliverables of this project are: (1) a technical report containing data of life cycle emissions and cost analysis of the three types of buses operated by Houston METRO and (2) showcase the findings of the study at the Final Technical Research Review Committee (TR^2C) meeting and the Tran-SET Conference.

This study's outcome is expected to be important in setting the direction of the sustainable development of public transportation in Houston METRO and further help the expansion of the Houston METRO system considering regional air quality and global warming potential in the future.

Tran-SET

Tran-SET is Region 6's University Transportation Center. It is a collaborative partnership between 11 institutions (see below) across 5 states (AR, LA, NM, OK, and TX). Tran-SET is led by Louisiana State University. It was established in late November 2016 "to address the accelerated deterioration of transportation infrastructure through the development, evaluation, and implementation of cutting-edge technologies, novel materials, and innovative construction management processes".

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