DRISI
Caltrans Division of Research, Innovation and System Information

Research Results

Planning, Policy, and Programming

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Project Title:
Technology, Sustainability, and Marketing of Battery Electric and Hydrogen Fuel Cell Medium Duty/ Heavy Duty (MD/HD) Trucks and Buses in 2020-2040

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Electric Technologies for Medium Duty/Heavy Duty (MD/HD) Trucks and Buses

The status of battery-electric and hydrogen fuel cell technologies was assessed for the medium-duty (MD) and heavy-duty (HD) vehicle markets and the markets which were most suitable for each of technologies identified.

WHAT IS THE NEED?

The California Sustainable Freight Action Plan includes goals of deploying over 100,000 zero emission (ZEV) vehicles by 2030. ZEV trucks will be powered by either batteries or fuel cells. The choice of ZEV vehicle technology will depend on a variety of considerations and will vary by application. Understanding the benefits and barriers associated with each technology will be critical to ensuring that sustainable freight goals are met in a viable, cost effective manner.

In order to meet the 2040 greenhouse gas reduction goals, most of the fuel for freight vehicles must come from sustainable energy sources. Research was needed to assess the battery-electric and hydrogen fuel cell technologies for truck applications; and to determine whether fueling those trucks could be done from sustainable energy sources.

WHAT WAS OUR GOAL?

The goal was to project how battery electric and hydrogen fuel cell technologies will be introduced into the MD/HD truck markets and to identify which markets will be suitable for each ZEV technology and what factors (technical, economic, and operational) will be most critical.

WHAT DID WE DO?

In the first phase of the study, the researchers assessed the current status of lithium battery and Proton Exchange Membrane (PEM) fuel cell system technologies and their application to trucks and buses. After determining the range (miles) and power requirements for various types of MD/HD vehicles, they simulated the operation of the vehicles on the computer to assess their energy usage and subsequently the energy storage requirements. This permitted the research team to develop a "paper design" for each vehicle type.

Then, they developed an Excel spreadsheet model to calculate the initial and operating costs of the ZEV vehicles for comparison with the cost values for the baseline diesel engine powered vehicle of each type. In the model, the cost of the battery and fuel cell system components were varied over time (2020-2050), as the ZEV technologies matured to determine for each vehicle type when and under what conditions they would be cost competitive with the diesel baseline vehicles. The researchers also developed cost models of the infrastructure for battery charging and hydrogen refueling with emphasis on using renewable electricity from wind and solar panels.

WHAT WAS THE OUTCOME?

The outcomes of the research were detailed descriptions of the "paper design" of various types of MD/HD vehicles using battery-electric and hydrogen fuel cell powertrains, the initial and operating costs of each vehicle type, and the system description and cost of the infrastructure needed to refuel the vehicles using sustainable energy sources.

The market analyses indicated that the ZEV trucks would be cost-competitive with the diesel engine trucks when the battery costs decreased to about $100/kilowatt hour and the fuel cell system cost decreased to about $100/kilowatt. At these component costs, the ZEV transit buses and MD city delivery vans will become economically attractive to the market first probably by 2025.

The research team also found that the cost of the infrastructure for battery charging was less costly and more readily available that needed to produce and dispense hydrogen in the quantities (kg) needed for trucks. It is expected that renewable electricity will be available for battery charging and producing hydrogen for the ZEV trucks. The cost of the electricity and hydrogen is uncertain.

WHAT IS THE BENEFIT?

The research results make a significant contribution to the literature on the technologies and economics of ZEV MD/HD vehicles for freight applications. The California Air Resources Board (CARB) is planning to establish a sales mandate for ZEV trucks beginning in 2023 and has already in place a transit bus mandate.

California Department of Transportation (Caltrans) requires to electrify their vehicle fleet by 2030. Those conversions will include battery-electric and hydrogen fuel cell powered vehicles. The results of this study should prove valuable to CARB and Caltrans, as well as the private sector that has to respond to the CARB mandates.

LEARN MORE

https://ncst.ucdavis.edu/project/technology-sustainability-and-marketing-battery-electric-and-hydrogen-fuel-cell-medium-and

IMAGES

Image 1: A Fuel-cell Transit Bus

Image 2: A Fuel-cell Powered Heavy-duty Truck

Image 3: A Battery-electric Bus