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Developing Markets for Zero Emission Vehicles in Short Haul Goods Movement

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Background

Achievement of a zero emissions vehicle (ZE) fleet is part of the long range plans for California, the South Coast Air Quality Management District (SCAQMD), and more recently the San Pedro Bay Ports and many local jurisdictions. A zero or near zero vehicle fleet is core to achieving California's greenhouse gas reduction goals. The use of ZEHDTs for freight movement remains a challenge particularly in the heavy duty sector. Zero and low emission technologies are not yet competitive with the traditional diesel engine for hauling heavy loads.

Project Objective

This research examines the potential for ZE or near-ZE vehicles with respect to freight operations, economic impacts, and environmental benefits. We focus on heavy duty trucks (HDTs) used in short-haul drayage services, one of the most promising market segments for early adoption. Drayage service is defined as short haul pickup and delivery of goods to and from ports, warehouse and distribution centers, and intermodal facilities. In order to provide a comprehensive assessment of the market potential for ZE and near-ZE HDTs, we consider several dimensions of their costs and benefits.

Technology Description

First, we consider impacts on freight operations. ZE HDTs have different performance characteristics than conventional diesel HDTs, namely range, load capacity, and refueling time. For a given set of pickups and deliveries, the number of trucks required depends on the range of the vehicle and its load capacity. These in turn determine miles traveled (including associated labor costs) and refueling time costs. Near ZE HDTs, such as hybrid electric, have similar performance characteristics to conventional diesel.

We develop a simulation model and use actual drayage trip data to generate a set of simple (single or two stop) drayage demands to be accomplished over a single eight-hour shift day. The simulation model optimizes routes so that total costs are minimized. Using an all diesel fleet as the base case, we use the simulation model to estimate the number of trucks required to serve all the demand. We incrementally introduce ZE trucks into the fleet with subsequent model runs. We run the model until the maximum possible number of ZE trucks is reached.

We consider three target years, 2020, 2025, and 2030, and three vehicle technologies: diesel, natural gas hybrid, and battery electric. Performance attributes for 2020 are based on data from field tests; attributes for 2025 and 2030 are based on most recently available data on expected improvements in the various technologies.

We conduct two case studies of short haul firms to test the potential penetration of ZEHDTs with more realistic truck activity. The case study data allows us to consider both range and charging constraints, as well as the additional effect of the gross vehicle weight restriction.

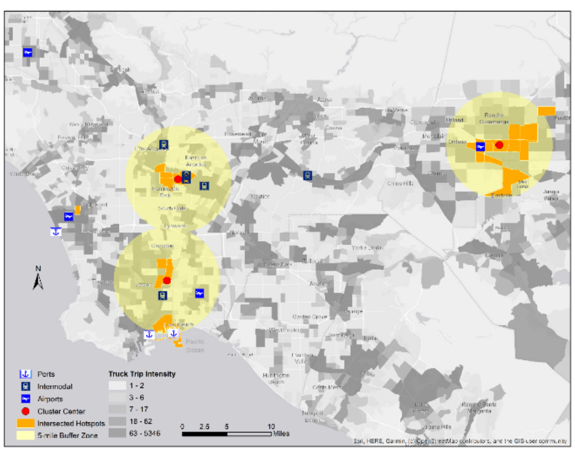
The simulation and case study research were supplemented with two rounds of interviews and a stated preference survey to gather information on trucking industry perspectives. Interviews were conducted with OEMs as well as drayage firm owners and operators. A market analysis of drayage activity concentrations was also conducted.

Status

This project has been completed and the final report was published in December 2020 on the METRANS website: https://www.metrans.org/research/developing-markets-for-zero-emission-vehicles-in-short-haul-goods-movement.

Figure 1 shows the main truck trip clusters in the Los Angeles Region based on regional transportation model data

Figure 1: Heavy duty truck trip clusters

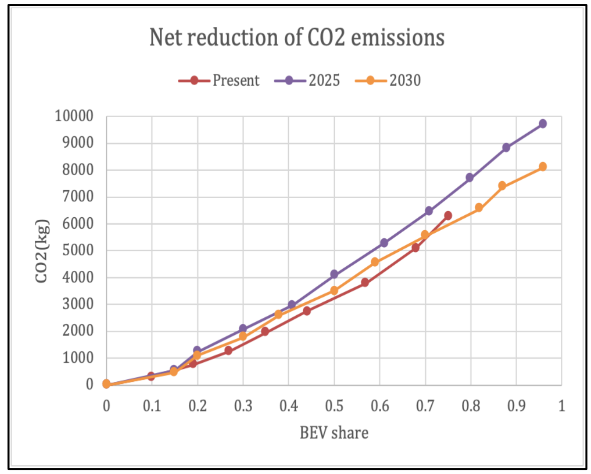


Results

Results show a clear trade-off between emissions reductions and larger BEV fleet size. In 2020, the maximum possible share of BEVs is 75% and requires a near doubling of the fleet. In 2025 and 2030, the maximum possible share rises to 96%, and the vehicle fleet increases by about one third in 2025 and 20% in 2030.

Increased fleet size adds to costs, leading to clear tradeoffs between emissions reductions and drayage costs. Figure 2 compares the net reduction of CO2 for the three target years.

Figure 2: BEV share and net CO2 reductions



Simulation results were used to generate four scenarios: all diesel, all NG hybrid, midpoint ZE, and maximum ZE. Diesel and hybrid trucks have similar range and refueling requirements, so differ only in emissions and costs. Annualized emissions savings relative to diesel were estimated. See Table 1. Max ZE has the greatest emissions net savings for all but NOX in 2020.

Table 1: Net annualized emissions savings

Net emissions savings	All NG Hybrid	Midpoint ZE	Max ZE
PM 2.5 (g)			
2020	2350	3525	8075
2025	1175	3150	7525
2030	1175	3275	7525
NOX (kg)			
2020	2725	675	1550
2025	1225	600	1425
2030	1225	625	1425
CO2 (kg)			
2020	1311500	687750	1576500
2025	1160500	1019750	2429500
2030	1040500	880500	2024000

The annualized cost per unit of emissions removed relative to diesel HDTs was estimated. Capital, vehicle operations, and driver costs were included. See Table 2. The all hybrid alternative is the least cost alternative for all emissions and all target years. This is due to the lower operating costs of hybrids and lower emissions relative to diesel. At the same time, the hybrid alternative does not require additional vehicles, and therefore has much lower capital costs than the ZE alternatives. The max ZE alternative generates modest savings in 2030, but of much lower magnitude than the hybrid alternative. Results illustrate the contrast between possible policy objectives. If reducing emissions is the most important objective, ZEHDTs meet that objective, but at very high cost relative to other alternatives.

Table 2: Incremental costs (savings)

Emissions	All NG hybrid	Midpoint ZE	Max ZE
PM 2.5 (per gm)			
2020	\$(130.74)	\$172.76	\$208.55
2025	\$(251.52)	\$21.79	\$19.27
2030	\$(222.68)	\$21.22	\$(9.41)
NOX (per kg)			
2020	\$(112.75)	\$902.21	\$1,086.49
2025	\$(241.26)	\$114.42	\$101.76
2030	\$(213.59)	\$111.18	\$(49.68)
CO2 (per kg)			
2020	\$(0.23)	\$0.89	\$1.07
2025	\$(0.25)	\$ 0.07	\$0.06
2030	\$(0.25)	\$0.08	\$(0.03)

Benefits

The main benefit of this project is incorporating freight operations into assessments of the market for zero emission heavy duty trucks in the short-haul market. The results present a more nuanced picture of what will be required to achieve pollution reduction targets. The project provides a set of findings and recommendations that can provide guidance for policy makers and regulators.

<u>Finding 1</u>: At the current state of BEV technology, BE ZEHDTs have limited application in the short haul heavy truck market. *Recommendation*: State and local policy should take into account the full impacts of ZEHDTs on freight operations and costs

<u>Finding 2</u>: Natural gas hybrid near zero vehicles are preferred in the short term. *Recommendation:* State and local policy should be more flexible and consider hybrid technologies as viable near and middle term options for GHG and other emissions reductions

<u>Finding 3</u>: The medium-term market is promising and depends critically on the rate of improvement of battery technology and rate of decline in vehicle price. *Recommendation:* Continue to promote and invest in battery technology improvements

<u>Finding 4</u>: The medium-term market depends on charging infrastructure and energy availability. *Recommendation:* Develop a comprehensive investment plan for public charging stations and identify a funding source

<u>Finding 5</u>: The medium-term market depends on subsidies. *Recommendation*: Develop a comprehensive subsidy and incentive program to promote ZE and near-ZE purchase and use, and fund at a sufficiently high level

Project Costs

SCAQMD	\$350,000
Caltrans	\$126,000
Volvo Research and Education Foundation	\$25,000
Majestic Realty	\$23,000
Total	**\$524,000**

Commercialization and Application

The results of this project can be applied to current and future rulemaking on emissions reductions in the heavy duty vehicle sector. The research should be extended to consider weight limits, a broader set of operating conditions, infrastructure costs and availability, and full life cycle costing.