Pacific Southwest Region UTC Research Brief

Evaluating Mixed Electric Vehicle and Conventional Fueled Vehicle Fleets for Last-mile Package Delivery

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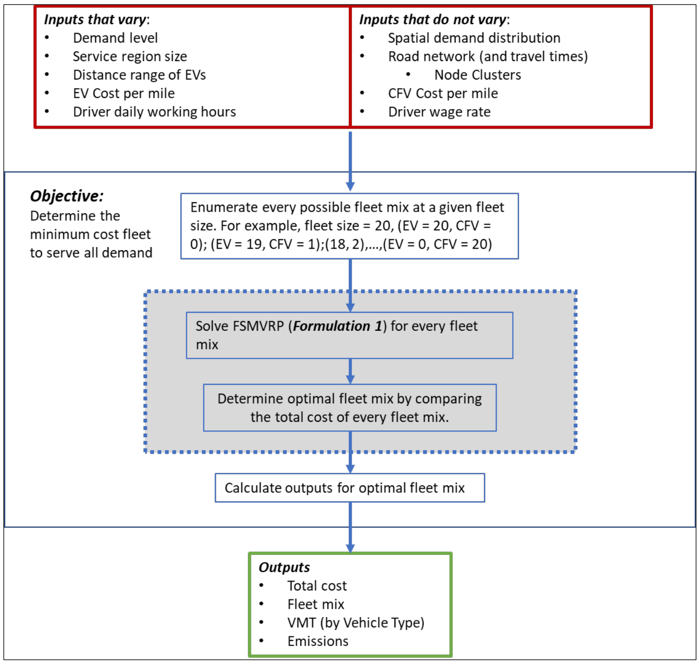
Project Objective

The goals of this study are two-fold. First, we aim to develop a modeling and analysis framework to determine the optimal (i.e., cost-minimizing) fleet size and mix of electric vehicles (EV) and conventionally fueled vehicles (CFVs), as well as EV and CFV routes for a profit-maximizing logistics company, where the modeling framework captures the essential costs and operational constraints associated with EVs and CFVs. Second, we aim to use the modeling and analysis framework to analyze the vehicle miles traveled (VMT) and emissions implications of a profit-maximizing logistics company's fleet size, fleet mix, and vehicle routing decisions, under various future scenarios. The effectiveness of subsidizing EV costs and the criticality of EV range in reducing tailpipe emissions are of particular interest.

Problem Statement

The motivation for this study is threefold: (i) freight transportation is a major contributor to global climate change and the emissions of harmful local pollutants, (ii) governments and logistics companies are setting goals related to transitioning freight delivery fleets to zero-tailpipe-emission vehicles, and (iii) there are substantial differences between EVs and CFVs that provide challenges and create opportunities for urban delivery fleets operated by profit-maximizing logistics companies. Given this motivation, we propose a modeling and analysis framework, to model the fleet size, fleet mix, and vehicle routing decisions of profit-maximizing logistics companies. The modeling framework considers the key costs and constraints associated with CFVs and EVs. With the proposed modeling and analysis framework, as well as data for Southern California, we hope to provide policy insights related to electrification policy (e.g., subsidies and EV mandates) for medium-duty delivery vehicles.



Research Methodology

Figure 1 displays an overview of the study's modeling approach. The model inputs include ones that vary across future scenarios of interest and those that are fixed. Given the inputs for a particular scenario, we solve a fleet size and mix vehicle routing problem for a logistics firm looking to minimize costs. We solve the problem using Google OR tools. The model outputs include total cost, fleet mix, VMT, and tailpipe emissions.

In this study, we develop a case study for the LA County and Orange County region of Southern California.

Results

The most important insights obtained from the case study and scenario analyses are as follows:

- EV range is the most critical factor for increasing EVs in urban delivery fleets. As EV range increases, the feasibility and cost of an all-EV urban delivery fleet decreases substantially—see Figure 1.
- The effectiveness of EV subsidies depends on (i) EV range, (ii) the size of a depot's service region, and (iii) the willingness of logistics companies to restructure their logistics networks. With short EV range values and large service regions, EV subsidies are highly ineffective if logistics companies are unwilling to restructure their networks.
    - Figure 1 provides insights into the interplay between EV range and the structure of service regions (i.e., one-depot vs. two-depot scenarios)
- Given that the range of CFVs is rarely a binding constraint for existing urban delivery services, it is not critical that EV range matches the range of CFVs. Rather, it is critical that EV range increases such that vehicle capacity or driver working hours constraints once again become binding.
- As demand increases within a service region, the importance of longer routes increases. Hence, as demand increases, the effectiveness and presence of EVs in urban delivery fleets decreases.

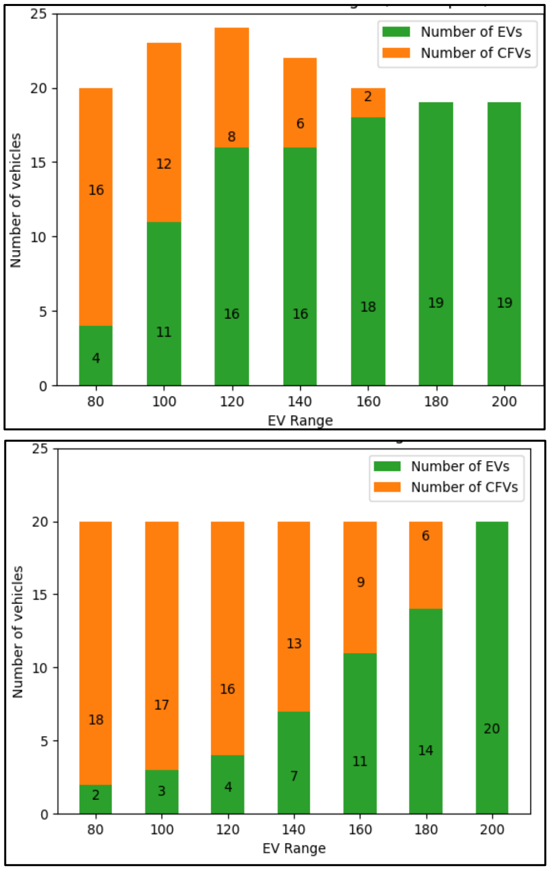


Figure 1: Optimal fleet mix as a function of EV range for one depot (top) and two depots (bottom) covering LA and Orange counties.

- VMT may slightly increase as urban delivery fleets transition to EVs (Figure 2); however, the tailpipe emissions benefits of EV delivery vehicles are substantial (Table 1).

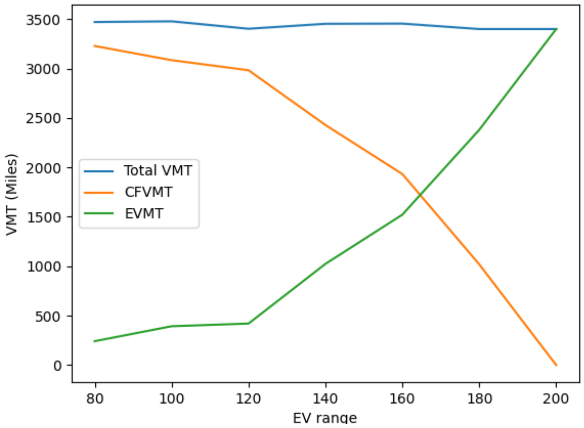


Figure 2: VMT for the optimal fleet mix as a function of EV range, broken down by fuel type

Table 1: Tailpipe emissions as a function of EV range and EV cost per mile

EV cost per mile→	**0.2**	**0.3**	**0.4**	***(All CFVs)***
NOx **120-mile EV Range**	793	793	821	*897*
NOx **160-mile EV Range**	484	595	599	*897*
PM2.5 **120-mile EV Range**	18	18	19	*20*
PM2.5 **160-mile EV Range**	11	13	14	*20*

Source: U.S.DOE, *Estimated U.S. Average Vehicle Emissions Rates per Vehicle-by-Vehicle Type Using Gasoline and Diesel. National Transportation Statistics, Table 4-43*.