Towards Vehicle Electrification: Traffic Analysis of Medium- and Heavy-Duty Vehicles in the Inland Empire

[1]Sai Kalyan Ayyagari, [1]Bhavik Pankaj Khatri, [2]Raffi Der Wartanian, [2]Kimberly Collins, [2]Yunfei Hou

[1]School of Computer Science and Engineering, California State University, San Bernardino
[2]William and Barbara Leonard Transportation Center, California State University, San Bernardino
[1]{ayyagarisaikalyan, bhavik11khatri}@gmail.com, [2]{raffi.derwartanian, kimberly, hou}@csusb.edu

ABSTRACT

In this study, we report on the traffic patterns of short-haul commercial trucks within the Inland Empire region of California during 2021. Our findings offer valuable insights into the operation of medium- and heavy-duty vehicles in this area and serve as a reference point in planning towards California's ambitious vehicle electrification goals.

1 Introduction

In this poster, we report our findings on the traffic patterns of medium- and heavy-duty vehicles in the Inland Empire region of California. Analyzing the traffic of local freight operations will provide insights into achieving California's ambitious goals for vehicle electrification. Furthermore, it lays the groundwork for exploring innovative solutions, such as opportunity charging and battery swapping, to support a more sustainable logistics industry.

Logistics and warehousing are the backbone industries of the Inland Empire, which consists of San Bernardino and Riverside Counties in Southern California. The Inland Empire hosts the second-largest logistics industry in the nation [1] and is home to more than 22,000 logistics facilities that support the twin ports of Los Angeles and Long Beach, as well as the movement of goods from Baja California. Therefore, the region experiences high traffic volumes from medium- and heavy-duty vehicles, which is the focus of this study.

California is a national leader in sustainable transportation and emission reduction. As part of the state's plan, the California Air Resources Board is developing Medium and Heavy-Duty Electric Vehicles regulations with the goal of achieving zero-emission truck and bus mobility by 2045 [2]. The current goal is to get a total of 3000 zero-emission drayage trucks, school buses, and transit buses on-road in 2025. Recently, the port of Long beach announced its plan to be a zero-emission seaport by 2035 [3]. The transition from traditional diesel-powered trucks to electric ones is a critical component of these plans, but it presents several challenges, including range anxiety, inadequate charging infrastructure, lengthy charging time, high costs among others. To address these issues, a better understanding of how medium- and heavy-duty vehicles operate in the region is essential, thus prompting our study.

2 Methodology

The Inland Empire covers more than 27,000 square miles of both Riverside and San Bernardino counties, with a population of approximately 4 million people. To better comprehend the traffic patterns within this expansive area, we divided the Inland Empire into six regions based on their unique social, economic, and geographical attributes. Our classification relies on the data presented by the California CPBS [4].

The **East (E)** region, also known as the Coachella Valley, served by the I-10 freeway, has seen new investments in logistics due to land availability and its position as a major east-west corridor for Los Angeles and the transport of agricultural products. The **North (N)** region, also known as the High Desert, is served by the I-15 freeway and SR-58. It has experienced a boom in warehousing and distribution centers due to its proximity to major transportation routes. The **North Center (NC)** region is a dense hub for logistics and warehousing facilities and is strategically located near the intersection of I-10 and I-215. These highways are key transportation arteries for long-haul, regional, and short-haul operations in the Inland Empire. The **South (S)** region, also known as the Temecula Area, served by the I-215 corridor, often supports retail operations and distribution to local stores and e-commerce fulfillment centers. The **South Center (SC)** region, served by the I-215 and SR-60, is vital for truck traffic. As a significant player in logistics and warehousing, this sub-region has seen massive growth in fulfillment and distribution centers, such as Amazon. The **West (W)** region is one of the most important transportation and warehousing hubs in southern California, hosting massive distribution centers served by the I-10 and I-15 freeways. These facilities, which are geographically

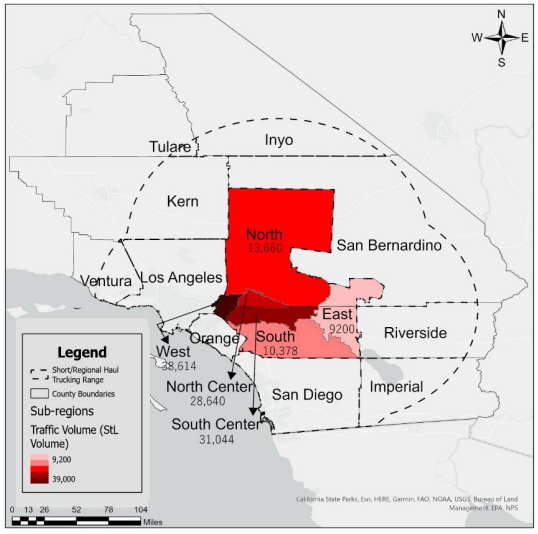

Figure 1: Overview of the Inland Empire Region and Short-haul Trucks Traffic Between Subregions

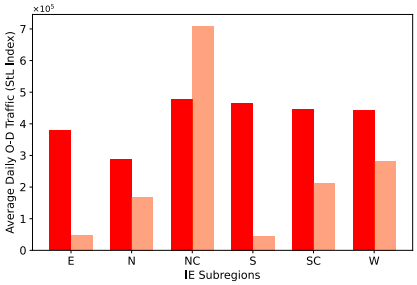

Figure 2

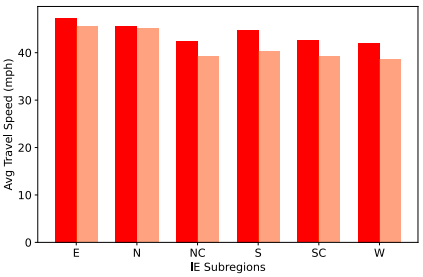

Figure 3

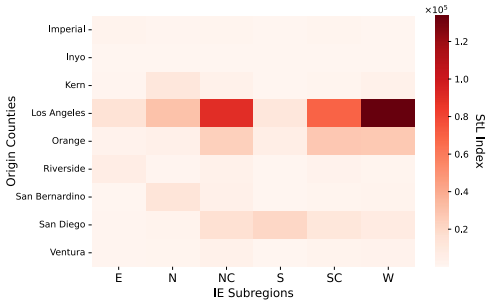

Figure 4

Figure 2: Average Daily Truck Traffic within IE Subregions. Figure 3: Average Truck Travel Speed within IE Subregions. Figure 4: Average Daily Truck Traffic to IE

dense, serve as a connection between the twin ports and the southern California region.

The primary data source for this study is StreetLight Data [5], which provides validated truck metrics for medium- and heavy-duty vehicles. StreetLight sources its data from third-party suppliers. For personal vehicles, data is collected through location-based services, while information about commercial trucks is gathered from their connected transportation management systems. Although StreetLight is a leading traffic data vendor, it has certain limitations. For instance, StreetLight Data provides aggregated data for time periods of 15 months or less, which means that the analysis was confined to a relatively short time frame. Our analysis was based on the traffic data from 2021, which was the most recent complete year of available data.

3 Results

Figure 1 presents the average daily traffic volumes of medium and heavy-duty vehicles between different subregions within the Inland Empire (IE), showing the traffic volume from one region to all the other regions in IE over the past year. The traffic volume is represented by StL Volume, which is the average daily count of vehicles recorded throughout the year. The West and South Center regions display significantly higher volumes, as they constitute the primary metropolitan areas in the IE. Conversely, the South and East regions exhibit lighter traffic, which can be attributed to these regions being less populated and largely comprised of mountains and deserts. These findings align with our expectations.

Figure 2 shows the average daily origin-destination (O-D) traffic of medium- and heavy-duty vehicles within each subregion, referring to trips that both start and end within the same region. The O-D pairs are represented by StL Index which are the normalized trip counts. Most of the trucking traffic within each region comprises medium-duty vehicles, which aligns with our observation that most short-range deliveries are fulfilled by these vehicles. Interestingly, the North Center region exhibits significantly more trucking traffic than any other subregion in the IE, and it is the only region where heavy-duty vehicles outnumber medium-duty ones. This is likely attributable to the high concentration of warehouses in this region. As we progress towards vehicle electrification, greater attention should be paid to the planning of charging stations in the North Center region. For instance, the frequent short trips present opportunities to implement opportunity charging during loading and unloading.

Given the number of short-haul truck trips within each subregion significantly exceeds those between subregions, we further examine the traffic patterns within the subregions. Figure 3 shows the average speeds of medium and heavy-duty vehicles within each subregion. We observe that, on average, trucks move smoothly throughout the IE, with the average speeds in metropolitan areas such as the West and South Center regions being only slightly slower than those in rural areas such as the North, South, and East regions. This suggests that the current road network effectively supports the logistics industry. Considering that the IE is likely to continue being an ideal location for logistics and warehousing, it is crucial to prepare for the further development of charging infrastructure to support this growth.

To investigate short-haul truck traffic beyond the IE, our study focused on trips that were within a 77-mile radius, which is a commonly used range for identifying short-haul electric trucking traffic [6]. This radius was measured from the center of each IE subregion, as indicated by the dashed line in Figure 1. Figure 4 shows the average daily traffic of medium- and heavy-duty vehicles that originated from each county zone and ended in the IE subregions. Figure 4 reveals that most of the incoming trucks to the IE originate from Los Angeles, Orange, and San Diego counties, which are nearby metropolitan areas with seaports. These figures also reaffirm our observation that the West, South Center and North Center regions in the IE receive the majority of truck traffic due to the presence of warehouses, railway stations, and airports. These findings underscore the need for prioritizing infrastructure that supports electric trucks along the freeways to these regions. The specifics of this need warrant further study.

REFERENCES

[1] Inland Empire Economic Partnership. (2022). Economic Report. http://ieep.com/

[2] California Air Resources Board. (2022). Advanced Clean Fleets | California Air Resources Board. Advanced Clean Fleets. https://ww2.arb.ca.gov/our-work/programs/advanced-clean-fleets/about

[3] Port of Long Beach. (2022). Port of Long Beach Takes Another Zero Emissions Step. https://polb.com/port-info/news-and-press/port-of-long-beach-takes-another-zero-emissions-step-11-18-2022/

[4] California Community & Place-Based Solutions (CBPS). (2023) https://economicdevelopment.business.ca.gov/inland-empire/

[5] Streetlight Data. (2023) Commercial Freight Truck Metrics Solutions. https://www.streetlightdata.com/commercial-freight-truck-metrics/

[6] Hannah Walter. (2023). Technical Memorandum. California Transportation Commission SB671. https://catc.ca.gov/-/media/ctc-media/documents/programs/sb671/sb671-technical-memo-030923-a11y.pdf