

USPS Zero-Emission Delivery Truck Pilot Commercial Deployment Project

Final Report

April 2020

Prepared for the San Joaquin Valley Air Pollution Control District by:

Thomas Paddon

Joseph Oldham

CALSTART



Acknowledgements

The USPS Zero-Emission Delivery Truck Pilot Commercial Deployment Project (Project) is part of California Climate Investments, a statewide initiative that puts billions of Cap-and-Trade dollars to work reducing greenhouse gas emissions, strengthening the economy and improving public health and the environment - particularly in disadvantaged communities.

The Project was made possible by the support of several individuals and companies. We would like to thank those who have provided insight and expertise that greatly assisted the Project. The San Joaquin Valley Air Pollution Control District (District) thanks California Air Resources Board (CARB) staff for their invaluable guidance, technical assistance, and comments that greatly improved the Project. In addition, the District would like to express its gratitude and appreciation to the following project partners and companies for their contributions to the successful implementation of the Project:



BLACK & VEATCH



Evolution Electric Vehicle Systems, LLC



Table of Contents

List of Acronyms3

Preface.....4

Executive Summary.....6

Chapter 1: Project Overview.....9

Chapter 2: Lessons Learned and Recommendations19

Chapter 3: USPS Future Intent for Trucks.....22

Chapter 4: Project Data.....24

Chapter 5: Contractor Listing.....31

Chapter 6: Appendix32

List of Acronyms:

AQIP	Air Quality Improvement Program
CAN bus	Controller Area Network
CARB	California Air Resources Board
Cal/EPA	California Environmental Protection Agency
DAC	Disadvantaged community
EDI	Efficient Drivetrains, Inc.
EV	electric vehicle
EVSE	Electric vehicle supply equipment (chargers)
FTA	Federal Transit Authority
GGRF	Greenhouse Gas Reduction Fund
HTUF	Hybrid Truck Users Forum
HVIP	Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project
ICE	Internal Combustion Engine
LLV	Life-Long Vehicles (door-to-door mail delivery)
PG&E	Pacific Gas and Electric Company
UDDS	Urban Dynamometer Driving Schedule
USPS	United States Postal Service

Preface

In 2007, the *California Alternative and Renewable Fuel, Vehicle Technology, Clean Air, and Carbon Reduction Act of 2007* (AB 118, Statutes of 2007, Chapter 750) was signed into law. AB 118 created the Air Quality Improvement Program (AQIP), a voluntary incentive program administered by the California Air Resources Board (CARB), to fund clean vehicle and equipment projects, air quality research and workforce training. As required in Health and Safety Code (HSC) Section 44274(a), CARB adopted regulatory guidelines in 2009 for AQIP. The Guidelines for the AB 118 Air Quality Improvement Program (Guidelines)¹ define the overall administrative requirements and policies and procedures for program implementation based on the framework established in statute. Central to the Guidelines is the requirement for a CARB-approved annual funding plan developed with public input. The funding plan is each year's blueprint for expending AQIP funds appropriated to ARB in the annual State Budget. The funding plan focuses AQIP on supporting development and deployment of the advanced technologies needed to meet California's longer-term, post-2020 air quality goals.

In 2012, the Legislature passed and Governor Jerry Brown signed into law three bills – AB 1532 (Pérez, Chapter 807), SB 535 (De León, Chapter 830), and SB 1018 (Budget and Fiscal Review Committee, Chapter 39) that established the Greenhouse Gas Reduction Fund (GGRF) to receive Cap-and-Trade auction proceeds and to provide the framework for how the auction proceeds will be administered in furtherance of the purposes of AB 32, including supporting long-term, transformative efforts to improve public health and develop a clean energy economy. The suite of implementing legislation offers strong direction for investing a portion of the auction proceeds to benefit disadvantaged communities, including specific allocation requirements in SB 535.

In 2014, the Legislature appropriated \$200 million dollars in GGRF monies to establish a Low Carbon Transportation GGRF program that ARB is implementing in coordination with the AQIP AB 118 programs. In May of 2015, Governor Brown's proposed budget included \$350 million dollars in GGRF monies toward the Low Carbon Transportation program. Projects funded by the Low Carbon Transportation GGRF program must reduce GHG emissions and further the purposes of AB 32, with a strong emphasis on benefiting disadvantaged communities.

In order to identify the priority investments that facilitate GHG emission reductions, the Legislature directed the development of the Cap-and-Trade Auction Proceeds Investment Plan (Investment Plan).² The 3-year Investment Plan, which was released in May 2013, calls for projects that support the large-scale deployment of alternative technologies, such as zero and near zero-emission vehicles, to help achieve the State's near-term and longer-term greenhouse gas (GHG) emission reduction goals. In addition, SB 535 directs at least 25 percent of funding from GGRF to be allocated toward projects that benefit disadvantaged communities and at least 10 percent to be allocated toward projects located in disadvantaged communities, as identified by the California Environmental Protection Agency (Cal/EPA).³

Also in 2014, the Legislature passed and Governor Brown signed Senate Bill 1204 (SB 1204) establishing the California Clean Truck, Bus, and Off-Road Vehicle and Equipment Technology Program (Chapter 524, Statutes of 2014) to be funded from GGRF. SB 1204 establishes specific requirements for prioritizing and

¹ The Guidelines for the AB 118 Air Quality Improvement Program are found in Title 13, California Code of Regulations, Chapter 8.2.

² The Cap-and-Trade Auction Proceeds Investment Plan is available at <http://www.arb.ca.gov/cc/capandtrade/auctionproceeds/investmentplan.htm>.

³ The identified disadvantaged community census tracts are available at <http://www.calepa.ca.gov/EnvJustice/GHGInvest/>.

selecting projects funded under GGRF and directs CARB to develop guidance for implementing GGRF funding through the AQIP Funding Plan process. Accordingly, the FY 2015-2016 Funding Plan for AQIP and Low Carbon Transportation GGRF Investments is designed to support development and commercialization of advanced technologies that are necessary to meet California's long-term air quality and climate goals. The Funding Plan identifies projects that (1) provide immediate emission reductions from the vehicles directly funded, and (2) set the stage for significant future emission reductions by accelerating large-scale market penetration and technology transfer to other sectors. Funding is provided for projects that support evolution through three phases of technology advancement: development, commercialization, and transition to widespread deployment. The FY 2015-2016 Funding Plan also details how CARB is addressing the specific requirements of SB 1204, including the requirement to establish performance criteria for disbursing incentive funds.

CARB's April 2015 *Sustainable Freight: Pathways to Zero and Near Zero Emissions* discussion draft document⁴ details a long-term vision for transitioning the freight sector to near-zero and zero-emission, and lists strategies for overcoming barriers to commercialization. The truck and bus commercial pilot projects funded under the Zero-Emission Truck and Bus Pilot Commercial Deployment Projects will support the Sustainable Freight document vision to overcome the technical and economic challenges with zero-emission technology advancement.

Funding for the Zero-Emission Truck and Bus Pilot Commercial Deployment Projects was approved by CARB through the FY 2014-2015 and FY 2015-2016 Funding Plans for AQIP and Low Carbon Transportation GGRF Investments.^{5,6} In approving the FY 2015-16 Funding Plan in June 2015, CARB approved staff's recommendation to combine zero-emission truck and bus pilot project allocations from the two fiscal years' Funding Plans into one Solicitation.

The Solicitation captured the types of technologies and pilot projects eligible for funding under both funding plans. However, the requirements tied to these pilot project funds in the FY 2015-2016 Funding Plan are slightly different than those in the FY 2014-2015 Funding Plan. The FY 2014-2015 Funding Plan requires that all zero-emission truck and bus pilot project funding go toward projects that benefit disadvantaged communities without stipulating specific funding amounts for truck versus bus projects. The FY 2015-2016 Funding Plan, on the other hand, specifies individual funding amounts for truck projects and bus projects, and requires that at least half of the bus funding go toward projects *located within* disadvantaged communities and half of the truck funding go toward projects that *benefit* disadvantaged communities,⁷ thus allotting limited funding for projects that need not benefit disadvantaged communities.

⁴ ARB, 2015a. *Sustainable Freight: Pathways to Zero and Near-Zero Emission*, Discussion Draft, April 2015. http://www.arb.ca.gov/gmp/sfti/Sustainable_Freight_Draft_4-3-2015.pdf

⁵ ARB, 2014a. *Final Approved Fiscal Year 2014-15 Funding Plan for the Air Quality Improvement Program and Low Carbon Transportation Greenhouse Gas Reduction Fund Investments*. Approved June 26, 2014. <http://www.arb.ca.gov/msprog/aqip/fundplan/fundplan.htm>.

⁶ ARB, 2015c. *Fiscal Year 2015-16 Funding Plan for Low Carbon Transportation Investments and the Air Quality Improvement Program*. Approved June 25, 2015. <http://www.arb.ca.gov/aqip>.

⁷ ARB, 2015d. *Proposed Cap-and-Trade Auction Proceeds Funding Guidelines for Agencies that Administer California Climate Investments*. September 4, 2015. These Funding Guidelines, which were approved by the Board on September 24, 2015, contain criteria for evaluating whether projects satisfy disadvantaged community requirements and are available at: <http://www.arb.ca.gov/cc/capandtrade/auctionproceeds/fundingguidelines>.

Executive Summary

Following on success and growing market acceptance with light duty cars, electric drive technology is rapidly being introduced as a powertrain option for light, medium, and heavy-duty vehicles. California has become an important world market for early deployment of these vehicles because of its policy and incentive leadership in finding solutions to improve air quality and combat climate change. Thanks to economies of scale resulting from the growing number of battery electric automobiles, this technology is maturing to the point where these vehicles can become operationally viable alternatives to the internal combustion vehicles they would be replacing in selected applications where the needs for range and performance fit the capabilities of this evolving technology.

As identified in CARB's "Three Year Investment Strategy for Medium and Heavy-Duty Vehicles", the first successful applications for electric drive in commercial vehicles were in the transit bus market⁸. Transit buses are characterized by central refueling, return-to-base operations, and route structures that generally match the range and power capabilities of the current state of battery and electric motor technology. CARB's same report identified transit buses as an important "beachhead" market for heavy duty electric vehicles for electric drive – a first market for successful operations, from which additional markets that could share some of the operational characteristics and components could then grow. Based on that report and the pathways it identifies, the next markets for success were forecast to include medium-duty electric delivery truck applications.

As validation for this forecast, the United States Postal Service (USPS), using funding from CARB and in collaboration with the San Joaquin Valley Air Pollution Control District (District), has led the USPS Advanced-Drive Transport and Delivery Vehicle Demonstration Project to deploy and test fifteen Class 4-5 battery-electric parcel delivery trucks used for package and mail collection services operating in the cities of Stockton and Fresno. This report documents the various learnings from the project starting from August 2017 through February 2020.

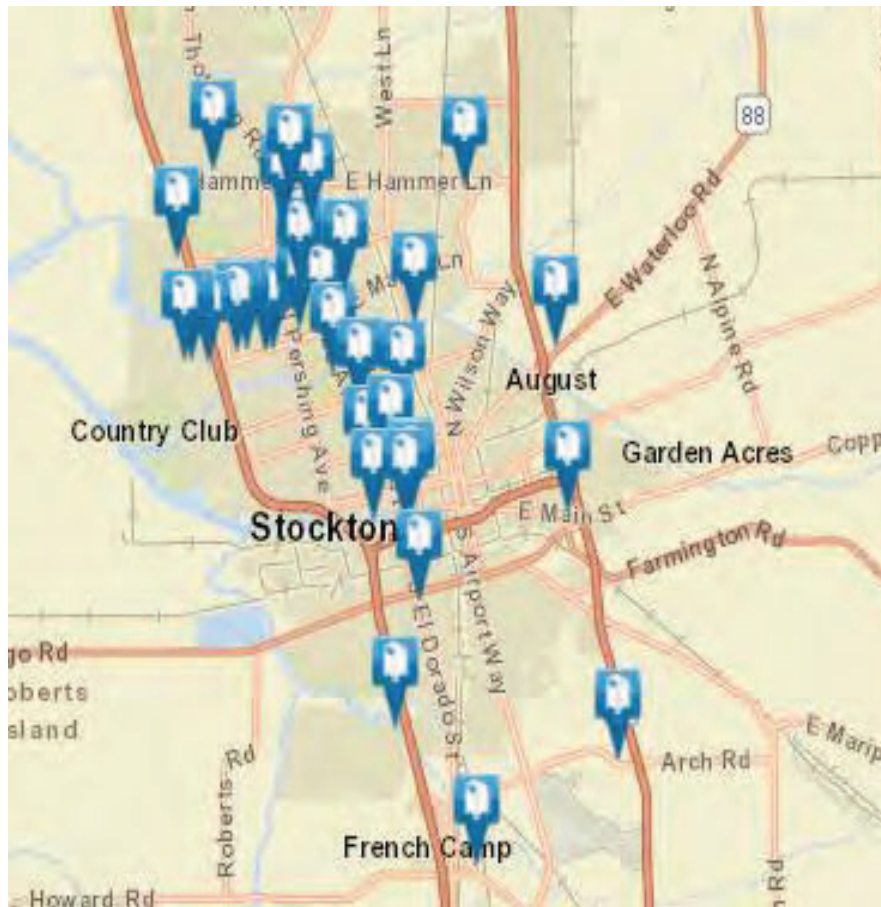
As part of the CARB solicitation for Zero-Emission Truck and Bus Pilot Commercial Deployment Projects, the District was awarded funding for a pilot project in Fresno and Stockton led by the USPS, in partnership with CALSTART, Efficient Drivetrains, Inc. (EDI), Motiv Power Systems (Motiv), Morgan Olson, and Black and Veatch (B&V), to demonstrate the commercial viability of electric-powered parcel delivery trucks to replace the conventionally-powered units in the USPS fleet.

The project involved deployment of fifteen (15) zero-emissions parcel delivery trucks and fifteen (15) charging stations at USPS locations in Stockton (5) and Fresno (10). The project was designed to prove the efficacy of electric-powered delivery vans for mail and parcel delivery duty cycles. The project began in June 2017 and will continue through February 2020 and include a full year of data collection that will be used to demonstrate the commercial viability of these vehicles.

The project plan called for the all-electric vans to be used in the same way as their conventionally-powered counterparts, covering distances of up to 70 miles per day. The goal was to show that these vehicles are just as reliable and easy to operate as the vehicles they were replacing. The project also considered other potential costs unique to electric vehicles, such as any electrical upgrades needed to support the installation of electric vehicle charging equipment. The project scope included an evaluation of how

⁸ https://ww3.arb.ca.gov/msprog/aqip/fundplan/proposed_1819_funding_plan.pdf

USPS Collection Boxes - Stockton



Each route varies in length from 15 - 70 miles, covering those distances in a 6 to 10-hour period. All parcel delivery trucks are parked overnight between the hours of 7 p.m. and 8 a.m. the following morning and this is when charging occurs.

The two key takeaways from the project are:

- Medium duty truck charging infrastructure can be challenging and expensive to deploy in large numbers and requires significant upfront planning to be done efficiently.
- Electric parcel delivery trucks can operate successfully as replacements for conventional fueled trucks, but the technology is still evolving and needs further refinement for widespread acceptance.

Chapter 1: Project Overview

Background and History

In order to test and validate the use of electric propulsion systems in parcel delivery trucks and the feasibility of using them in operations within the San Joaquin Valley, Motiv, EDI (later acquired by Cummins), CALSTART, and Sun Edison (later replaced by B&V) partnered with the District and USPS to deploy fifteen (15) Class 4 zero-emission all-electric parcel delivery-vans (“Class 4”) and fifteen (15) Clipper Creek Level 2 Electric Vehicle Support Equipment (EVSE) (8 3-phase CS-100-3Ps and 7 HCS-80s) to support parcel delivery routes in the disadvantaged communities of Stockton and Fresno. The project was first conceived during the summer of 2015 and the project team applied for funding from CARB under the Zero-Emission Truck and Bus Pilot Commercial Deployment Projects solicitation in January 2016. Contracting was completed in 2017 and work on the project began that year.

Project Funding

	Cummins	MOTIV	CALSTART	BV	USPS	SJVAPCD	Totals
Grant Awards	\$ 1,870,423	\$ 1,929,506	\$ 651,966	\$ 35,441	\$ -	\$ 68,334	\$ 4,555,670
In-kind Match Funds	\$ 642,200	\$ 321,441	\$ -	\$ -	\$ 1,429,262	\$ -	\$ 2,392,903
Totals	\$ 2,512,623	\$ 2,250,947	\$ 651,966	\$ 35,441	\$ 1,429,262	\$ 68,334	\$ 6,948,573

Objective

The project objective was to deploy five (5) battery electric Class 4 parcel delivery trucks and five (5) EVSE at the main post office in Stockton and deploy ten (10) battery electric Class 4 parcel delivery trucks and install ten (10) Electric Vehicle Supply Equipment at the main post office in Fresno to demonstrate the efficacy of electrified delivery vehicles for the USPS. Both of the post office locations are in disadvantaged communities with high levels of exposure to toxic air contaminants, making the use of zero emission electric delivery trucks very valuable in reducing vehicle emissions for residents and workers in those communities. Besides providing environmental benefit, each battery electric Class 4 parcel delivery truck was estimated to provide a projected net savings of \$2,800-\$4,800 annually in operational costs for the USPS.

The plan was to replace all the existing conventional fueled Class 4 trucks at each site with electric units. The Class 4 trucks are used to pick up mail from large facilities and collection boxes in each city with range requirements up to a maximum of 70 miles; both technology providers had indicated their powertrains could handle that requirement.

Implementation

EVSE Installation

The ordering and initial construction of the trucks for the project was routine and comparable with internal combustion powered trucks of the same size, but component issues with the powertrains and debugging the systems after initial construction created delays in delivery and with vehicles entering service. There were also significant delays with the installation of EVSE at both the Stockton and Fresno facilities. After obtaining estimates for the EVSE installation, it became clear that there were not enough grant funds to cover the cost. As a result, an agreement was worked out amongst all the project partners and CARB to re-allocate grant funds from milestone 9 (Commercialization Activities) and milestone 10 (Field Use and Operational Support). This reallocation would be offset by an increase in match fund investments by Motiv, Cummins, and USPS. Once the additional funding was identified and reallocation plan approved by CARB,

CALSTART took on the role of EVSE construction manager and moved forward with the installation of the equipment using an approved USPS contractor.

Manufacturer	Class	Usable Battery	Location	Qty	EVSE Manufacturer	EVSE Model	Qty	Max Power	Connector	Material Costs	Installation Costs	Drawings	Total Cost	Installation Time
Motiv	Class 4	84.8 kWh	Stockton	3	Clipper Creek	CS-100-C7-L25-30, 3 Phase	3	19.2 kW	Meltric	\$11,794.71	\$21,004.20	\$3,000.00	\$35,798.91	30 days
Motiv	Class 4	84.8 kWh	Fresno	4	Clipper Creek	CS-100-C7-L25-30, 3 Phase	4	19.2 kW	Meltric	\$15,152.18	\$57,724.40	\$2,414.00	\$75,290.58	52 days
EDI (Cummins)	Class 4	99.5 kWh	Stockton	2	Clipper Creek	HCS-80-C16-L25-94	2	15.4 kW	SAE-J1772	\$3,675.74	\$14,002.80	\$2,000.00	\$19,678.54	30 days
EDI (Cummins)	Class 4	99.5 kWh	Fresno	6	Clipper Creek	HCS-80-C16-L25-94	6	15.4 kW	SAE-J1772	\$10,115.68	\$86,586.60	\$3,621.00	\$100,323.28	52 days

EVSE Installation Costs

	Stockton	Fresno
EVSE	\$ 15,470	\$ 25,267
Make-ready	\$ 40,007	\$ 150,346
Total	\$ 55,477	\$ 175,613

Cost per EVSE	\$ 11,095	\$ 17,561
----------------------	------------------	------------------

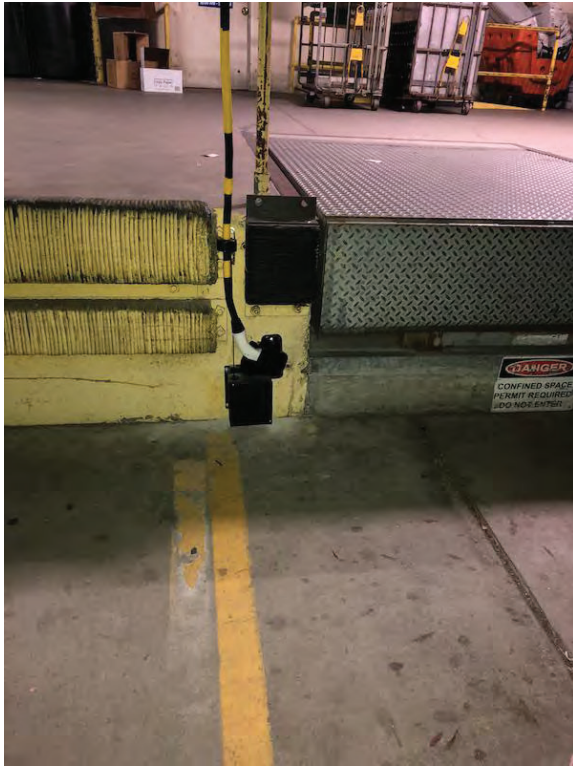
At the Fresno facility, the first EV Class 4 arrived before the EVSE was installed, so a temporary EVSE had to be set up to charge the vehicle. By the time the remaining EV Class 4s were delivered to Fresno, the EVSE had all been installed and were fully functional. The installation in Fresno was over twice the cost of the Stockton installation because of the added complexity of the installation at the site and the greater number of chargers which put more strain on the facility electrical system. Fresno needed a new transformer, facility electrical panel upgrades, and USPS wanted the EVSE installed in the parking lot, so trenching from the main building was needed, and the installation of bollards was required to prevent damage to the equipment from truck operations. The installation process was carefully planned to avoid undue disruption to the facility operations and was completed without incident.



Images from Fresno Site (photos courtesy of CALSTART)

The EVSE at the Stockton facility had already been installed by the time the first EV Class 4s arrived. Vehicles were placed into service approximately one week after they were delivered. Installing EVSE in Stockton proved to be considerably more challenging than originally envisioned. The parking spaces next to the dock that were made available by the USPS turned out to be less than ideal since the dock area was regularly being used by mail carriers and bulk mail customers. The charger installation had to be carefully engineered to eliminate trip and fall hazards and to still be easy for drivers to use. The installation also had to account for the unit being vulnerable to being struck by a mail cart, so it was decided to mount

the EVSE in the ceiling. The charger cables were suspended by a strain relief and were positioned to drop down at the charge port location. A holster was mounted on the side of the dock to enable it to be stored out of the way when not in use.



Original Design (photo courtesy of CALSTART)



Revised Design (photo courtesy of CALSTART)

This design was not ideal due to the location of the charger plug being exposed to damage from a vehicle backing up to the dock and had to be revised as shown in the photos above. In addition, because the parking spaces are close together, as the EV Class 4s are being charged, there is very little egress room to pass between the vehicles. With the charger plugs protruding from the sides of the trucks during charging, these tight spaces create a situation where the charger plug is prone to damage by people passing between the trucks. The charger connections for the Cummins trucks have been damaged repeatedly; presumably by people trying to squeeze by them. The Cummins vehicle chargers (Clipper Creek HCS-80s with J1772 connectors), are not able to withstand the impact of people running into them while passing between the vehicles. Two of the three connectors have been damaged, and only one charger was working at the time of this report.

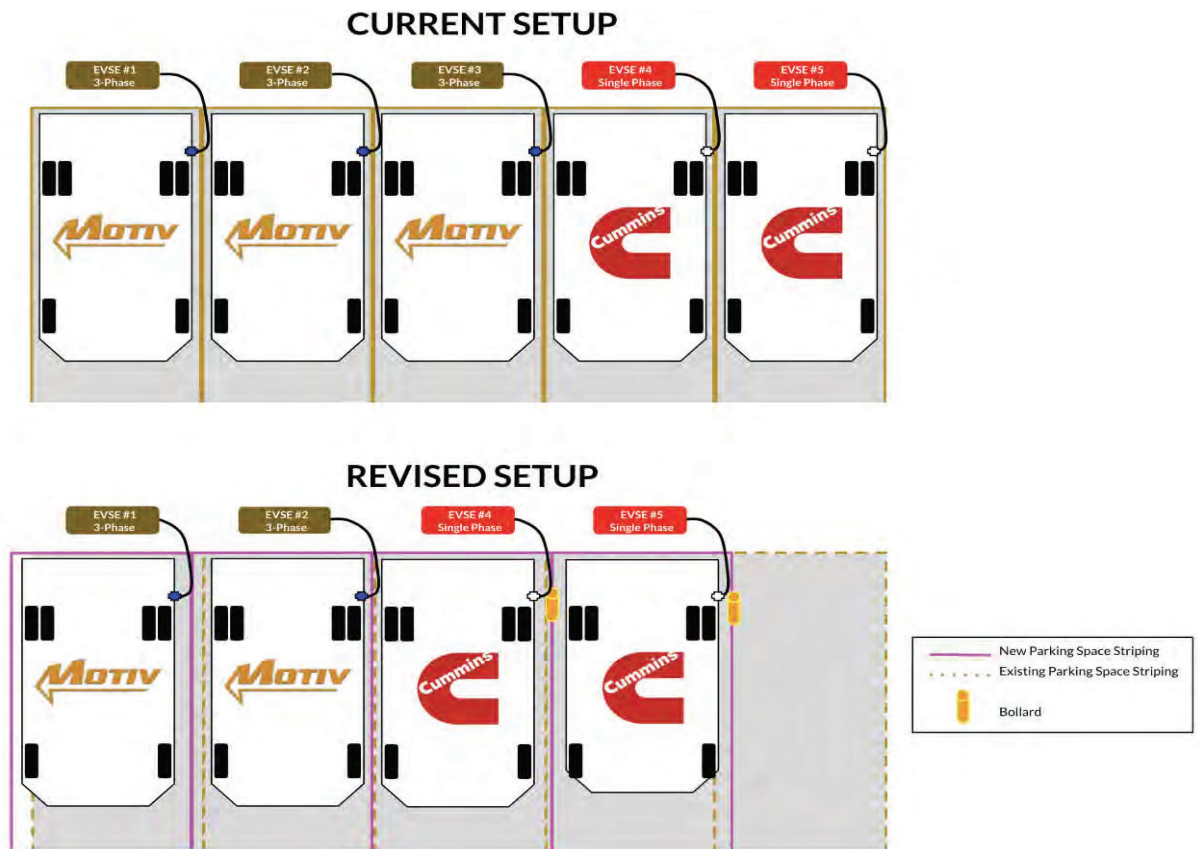


Cummins Truck Charger Plug (photo courtesy of CALSTART)



Motiv Truck Charger Plug (photo courtesy of CALSTART)

The Motiv EV Class 4 chargers use a different connector design (Meltric) and are quite robust, which makes them less prone to damage by people passing by them during charging. However, the decision to mount the charge ports on the fuel tank cutout is problematic, since the Meltric connectors extend about 18 inches perpendicular to the vehicle when attached. In at least one instance, another vehicle hit this connector while backing up, disconnecting the charge connector mounting plate on the vehicle. USPS is evaluating making more room for each truck as a potential solution to reduce potential EVSE damage.



The EVSE installations were originally estimated to be completed by October 2018. Due to the delays caused by lack of funding and complications with installation of infrastructure at each site, the EVSE installation wasn't completed until December 2018 in Stockton and March 2019 in Fresno.

EV Truck Deliveries

Motiv

All seven chassis were shipped from Ford to Morgan Olson in February 2018. Morgan Olson attached bodies onto the chassis and delivered them to ECO for up-fitting by April 2018. The first EV Class 4 was delivered to Motiv's Foster City location in August 2018, and then sent to Fresno in October 2018. Motiv was not able to deliver their second EV Class 4 until six months later due to quality control problems with their component suppliers. This issue was resolved and the remaining EV Class 4s deliveries were completed by the middle of May 2019.

	Location	Delivery Date
Vehicle #1	Fresno	10/9/2018
Vehicle #2	Stockton	3/28/2019
Vehicle #3	Stockton	4/2/2019
Vehicle #4	Fresno	4/9/2019
Vehicle #5	Fresno	4/23/2019
Vehicle #6	Fresno	5/15/2019
Vehicle #7	Stockton	5/18/2019

Cummins

Eight vehicle chassis were shipped from Ford to Morgan Olson, and Morgan Olson attached bodies onto the chassis and delivered the gasoline-powered USPS parcel delivery trucks to Cummins in February 2018. Cummins removed the internal combustion engine (ICE) components and installed their electric drivetrain, and the first EV Class 4 was completed and delivered to the Fresno location in February 2019. The remaining EV Class 4s were delivered by the middle of May 2019. However, technical issues have resulted in some Cummins trucks being out of service for extended periods following delivery. As of February 2020, three EV Class 4s were out of service, but both sites have spare EVs as part of the project, so the impact to USPS operations was negligible.

	Location	Delivery Date
Vehicle #1	Stockton	2/22/2019
Vehicle #2	Fresno	4/22/2019
Vehicle #3	Stockton	5/1/2019
Vehicle #4	Fresno	5/3/2019
Vehicle #5	Fresno	5/3/2019
Vehicle #6	Fresno	5/10/2019
Vehicle #7	Fresno	5/10/2019
Vehicle #8	Fresno	5/10/2019



Typical Project Truck (photo courtesy of CALSTART)

Data Collection

Data collection for all EV Class 4s was originally planned to begin no later than January 1, 2019. However due to overall project delays with contracting, truck deliveries, and EVSE installation, data collection was not started until April 1, 2019 and will be reported through the end of the project in March 2020.

Project Changes

Compared with the scope from the original proposal, CARB has approved the following changes:

- **Change #1 - Shift funds from Field Use Reports and Commercialization Activities to Infrastructure Tasks.** To cover the cost shortfall for the installation of the EVSE, CARB approved the reallocation of \$192,474 in project funds to CALSTART (\$74,970 from milestones 3 & 7 from Motiv and Cummins; \$127,500 from milestones 9 & 10 from Motiv, Cummins and CALSTART). An additional \$42,500 in cash

was contributed by USPS which reduced their in-kind match commitment. Motiv agreed to increase its match funds commitment to \$42,500. Cummins agreed to increase their match commitment to \$127,500. The match funds from both technology partners totals \$170,000 which offsets the grant fund reductions.

· **Change #2 – Increased Match Fund Commitments.** To ensure the modifications listed in Request Change #1 do not adversely impact project deliverables, several partners are contributing additional match funds to offset the amounts reallocated for the EVSE installations. The USPS has paid \$42,500 to CALSTART for its share of the EVSE installation costs. This amount was deducted from their original cash match commitment, so their overall match funds remains the same. Cummins provided \$127,500 in-kind match, which covers the additional match of \$42,500 each that CALSTART and the USPS would have otherwise had to spend on behalf of the project. Cummins had to undergo several design iterations to meet the USPS specifications, and as a result, ended up spending more on this project than they had planned.

· **Change #3 – Shift a portion of the funds from Data Logger equipment to Data Analysis; Decrease number of Data Loggers.** The solicitation required that data loggers (at \$2,000 per data logger) be included in the application, in case a project would be included in an independent third-party data contractor contract CARB was working to implement concurrent with the solicitation for this project. This project was not selected to be part of that contract, so funding included for the data loggers would not have been used. CARB approved the reallocation of \$46,318 from milestone 6.4 as follows: \$20,974 to a newly created milestone 2.5 for data analysis, and \$25,344 to increase the milestone 2.4 funding amount to \$32,470. The total number of data loggers was reduced to 16:

ViriCiti Data Loggers (EV Class 4s)

- 2 on Stockton Motiv EV Class 4s
- 2 on Stockton Cummins EV Class 4s
- 3 on Fresno Motiv EV Class 4s
- 3 on Fresno Cummins EV Class 4s

Fleet Karma Data Loggers (ICE baseline Class 4s)

- 1 on Tracy ICE Class 4
- 2 on Modesto ICE Class 4s
- 1 on Merced ICE Class 4
- 2 on Fresno ICE Class 4s

· **Change #4 – Modifications and Clarifications of the Commercialization Activities Deliverables.** In order to better support the current market needs and to make the best use of the reduced data collection timeline, CALSTART has submitted changes and deliverable clarifications for the milestones in Task 9.0 which were approved. These changes included: conducting a Voice of the Customer event to promote discussions about vehicle requirements and duty cycles, overview of project performance, presentations on infrastructure and results from B&V's work on solar feasibility. Furthermore, extensive changes to Milestone 9.5 included: development of a PowerPoint presentation on findings and shared via CALSTART webinar in March 2020.

· **Change #5 – Timeline Updates.** Several unexpected challenges have significantly impacted the projected timeline of the project. The subcontracts took longer to execute than was anticipated. The complexity of capturing and adjusting all the application items into contracts with all the team members took many months. We also needed to bring in a new engineering partner for the solar and energy storage evaluation, B&V, to replace Sun Edison which was not able to participate due to financial considerations.

Infrastructure installation was more challenging than originally planned which caused several months of delay and resulted in cost overruns that resulted in further delays as the funding was identified to cover the added construction costs. Finally, the build time of the EV Class 4s took longer than was envisioned in the application, which was due to issues with suppliers and challenges meeting all of USPS specifications.

· **Change #6 – Key Personnel Changes.** All project partners experienced various personnel changes since the project began.

· **Change #7 – Change “EDI” references to “Cummins.”** EDI was acquired by Cummins, so the grant amendment was modified to reflect that change.

Project Status

Vehicle Miles Traveled

All fifteen (15) electric delivery EV Class 4s have been delivered and placed into service. As of February 2020, these vehicles had been driven a total of 48,540 miles since being placed in service. A comparable number of ICE trucks drove 76,758 miles during the same time period.

Achieving full utilization of the EV Class 4s on routes has been challenging. In both locations, Cummins EV Class 4s were routinely pulled out of service for technical upgrades and component replacements early in the deployments. There were several unfortunate events where EV Class 4s became disabled while on a route and had to be towed back to the facility. As temperatures increased during the summer months, drivers started to notice that the air conditioning was not as effective in cooling the cabin as the ICE Class 4s, and that heavy use of air conditioning reduced EV Class 4 range.

Dispatch Reliability/Quality Control

The first vehicles delivered were prone to breakdowns due to various technical issues with the powertrains. Software had to be upgraded manually, since no over-the-air (cellular) services were provisioned. Problems were usually traced to faulty components as well as issues with software integration. The following is a list of components that Motiv and Cummins had to replace in order to improve operational reliability (some items were replaced on multiple trucks):

Component Replacements

- 1) Power Control Unit
- 2) Battery Monitoring Interface
- 3) Charger
- 4) Battery Replacements (High Voltage)
- 5) Master Control Unit
- 6) Telematics Data logger
- 7) Charge port harness
- 8) Cabin Heater
- 9) Cabin Air Conditioning Unit
- 10) Adaptive Power Controller (Bi-directional DC/DC converter)

11) DC/DC converter replacement

There were a variety of technical issues, but it appears most problems were fixed with software upgrades and the selected component replacements identified above. Beyond that, some quality control issues were identified and corrected:

Quality Control Issues

- 1) Repair power steering fluid leak
- 2) Tighten loose connections (various)
- 3) Fixed connections to Controller Area Network (CAN) bus, motor and Battery Disconnect Unit
- 4) Fixed coolant flow for the charger

Both technology providers have worked hard to address and correct issues with the trucks using field service (Motiv) and local dealer networks (Cummins). Reliability has been a challenge for these early production EV Class 4s; the early issues have been worked out and the trucks are operational.

Performance

Range

Cummins has stated that their EV Class 4, which has a useable battery capacity of 99.5 kWh, will go 71 miles on the Hybrid Truck Users Forum (HTUF) cycle, and 76 miles on the Urban Dynamometer Driving Schedule (UDDS) cycle for an average range of 71 miles.

Motiv has stated that their EV Class 4, which has a battery capacity of 106kWh with 84.8 kWh usable, will go 75 miles on a charge.

Battery Comparison	Weight	Size (usable)	Type
Cummins	2,364 lbs.	99.5 kWh	NMC/G Li-ion module
Motiv	1,815 lbs.	84.8 kWh	Sodium Nickel battery

Drivers report that the Cummins EV Class 4 has enough range for most routes, even when the air conditioning is being used. The range of the Motiv EV Class 4 falls short however, especially if the air conditioning is being used. Drivers of Motiv EV Class 4s often need to return to the USPS facility to swap vehicles midday for this reason.

Reliability

The reliability of the EV Class 4s was a major concern during the early rollout period. Fortunately, the project included a number of spare trucks into each site’s allocation so that service could be maintained if there were early downtime issues with the trucks. (2 spares in Stockton, 4 spares in Fresno). In addition to early technical challenges, the air conditioning systems on the trucks have not performed as well as the engine-driven units in conventional ICE Class 4 trucks. One of the reasons it has been challenging to achieve full utilization of the EV fleet is due to the air conditioning in the EV Class 4s not performing as

well as the ICE EV Class 4s, which discouraged their use during the hot summer months in the San Joaquin Valley.

Driver Feedback

Driver feedback has been consistent across the different locations. The primary concerns from drivers have been with acceleration, top speed and range with the Motiv EV Class 4s, causing drivers to choose the Cummins or ICE Class 4s instead. Drivers have noted that the slow acceleration with the Motiv EV Class 4 trucks is most concerning when the units must be taken on the freeway. Merging safely onto freeways packed with a long line of semi-trucks and cars requires some careful planning, but with encouragement, drivers are willing to use the Motiv EV Class 4s.

USPS reports that their drivers have adapted to using EVs, and quickly adopted the habit of plugging in the EV Class 4 at the end of the day so that it is fully charged for the next day. Driver surveys conducted by the USPS are contained in the Appendix, but results are mixed as to whether drivers prefer the electric trucks compared with conventionally powered units.

USPS Management

USPS is very interested in clean zero emission technologies, but the business case to justify the higher initial purchase price using an offset from operational savings doesn't always make sense for them to make the investment. For example, their rural delivery vehicles travel on average 18 miles per day. This mileage is too low for the economics to favor electric vehicles, even though the ICE vehicles only average 8 miles per gallon.

USPS conducted surveys of management staff at both locations and those surveys are contained in the Appendix. Management views of the electric trucks tend to be more positive than the drivers, but there are still mixed results on whether an all-electric delivery fleet would be welcome.

Chapter 2: Lessons Learned and Recommendations

The project has produced many lessons learned that have already been valuable as new projects have been implemented using CARB funding. The listing below describes some of the original plans of the project team, how those ideas had to be revised, and how these lessons can be applied to future projects.

EVSE Installation

Issue: Inadequate EVSE installation budget.

The original project budget allocation to deploy the EVSE to support the EV Class 4 truck operations was too low to cover the actual cost. This was due to not taking enough time during the original project scope development to understand the electrical load capacity of the two sites and build in adequate funding to cover the costs for transformers, panel upgrades, trenching, and custom engineering of the charger mounting.

Lesson Learned: Medium and Heavy Duty EVSE installation needs careful early planning and engineering to ensure adequate funding is allocated. Project developers should engage an electrical contractor or engineer early to evaluate the potential sites for EVSE installation to make sure that the facility can handle the added electrical load. This evaluation should also consider the electric utility capacity and if utility level upgrades are going to be required as part of the project and what those upgrades will cost.

Issue: Location of chargers created logistical and operational issues for end-user.

The need to locate the EV chargers on the dock area in Stockton has led to damaged charger connections and safety concerns with mail delivery activities. Special engineering of the charger cords was necessary to reduce “trip-and-fall” hazards, as well as having to mount the chargers in the ceiling of the dock area which created an added cost concern with maintenance or repair. The Fresno site had an issue with cords on the chargers being too short for all the trucks to be able to be parked facing the charger pedestals so backing could be avoided.

Lesson Learned: Potential sites for deployment of electric trucks need to be evaluated carefully prior to selection for the impact on operations with the installation of EVSE. EVSE should be in areas free of normal business operational traffic to avoid disruption for the end-user and potential safety issues with cords. EVSE should also be installed close to the main power supply for a given facility to avoid trenching costs and disruption of operations during trenching for installation. EVSE should also be located for ease of maintenance and repair and to allow for safe movement/parking of the trucks for charging.

Electric Trucks

Issue: Truck performance was different between manufacturers.

The original plan was to have two different manufacturer’s products demonstrated at each site. However, the truck performance was not identical between manufacturers and this created issues with drivers preferring one manufacturer’s product over another during the evaluation, which diverted attention from the goal of the project to validate the feasibility of electric trucks in parcel delivery service for the USPS.

Lesson Learned: An alternative scenario would have been to have only one manufacturer’s product demonstrated at each site, if two different products were going to be demonstrated. The focus could be

to only demonstrate one manufacturer's product with a given end-user, therefore eliminating product comparison between manufacturers and ultimately providing a scenario where only the technology is evaluated as compared with a conventional powered truck in the same application.

Issue: Trucks were prone to break-down and reliability issues after delivery.

The trucks from both manufacturers suffered from component failures, quality control issues, and the need for software updates that resulted in downtime and reliability issues after delivery. This created an impression early in the project with drivers and maintenance staff at the USPS sites that the electric trucks were not as reliable and did not perform as well as the conventional trucks they were designed to replace.

Lesson Learned: Trucks with new technology need to be thoroughly tested before delivery to the end-user to avoid the perception they are inferior to conventional trucks due to early development issues being unresolved. "First articles" or "sample units" need to undergo extensive reliability and endurance testing at recognized testing facilities such as the Transportation Research Center (<http://www.trcpg.com/>) before production units are built. While this would potentially add more cost to production of new truck designs, it would provide assurance for the end-user that the truck performance will meet their requirements and the systems have been tested for reliability before the first units arrive for service. This approach is similar to what the Federal Transit Authority (FTA) requires for new transit bus manufacturers before their products are eligible for Federal funding. FTA requires Altoona testing of new transit buses to protect transit agencies from receiving bus products that don't perform and/or have a high failure rate in service. A similar testing for new electric trucks would benefit the transition for fleet customers to electric powertrains by providing them with some type of certification that the new truck product has been tested and passed an objective testing program that validates performance.

Issue: Local truck support was needed from the beginning.

In the initial project design, Motiv had planned to contract with a local firm in Fresno County to provide support for their drive-train system once the trucks were delivered and placed in service. EDI was purchased by Cummins soon after the project started, and they planned to use local the Cummins engine support dealer network to support their drivetrain systems once the trucks were in service.

In practice, the local firm Motiv had planned to use ceased operations soon after the trucks were delivered, creating the need for Motiv to provide product support services from their main office in the Bay Area. Motiv stepped up to this challenge and provided very good support for their drivetrains creating a very positive impression with the USPS staff. Cummins (formerly EDI) has been successful at using their dealer network to support the electric drivetrain, but the process to get the dealership staff trained took some time and many of the trucks were initially returned to their final assembly point near Sacramento for work to be completed. This created longer downtime events which were unnecessary had there been more local support available. Both drivetrain providers have recognized the need for local support of this new technology and have taken steps to address this. Motiv has now opened a new support location in Stockton and Cummins is providing more support for their product through their local dealer network.

Lesson Learned: Early deployments of electric medium and heavy-duty trucks require good local maintenance and product support to address the inevitable technology "teething" problems that are associated with new products in order to be successful. In this project, both technology drivetrain providers have accepted the responsibility for providing that local support and have stepped up to the challenge. Future demonstration projects should be centered on established local support networks for the technology provider until the technology is more mature and widespread. Using this criteria, future project

development will leverage investment made by technology providers through early vehicle deployments and provide a greater opportunity for successful acceptance by the end user.

Recommendations

The following recommendations are based on the experience and lessons learned from the project. The items listed for consideration are intended help future projects avoid the challenges faced by the project team in completing the USPS Zero-Emission Delivery Truck Pilot Commercial Deployment Project.

1. CARB should consider requiring future project proposals that include construction of new EVSE to include evidence that the proposed sites have been evaluated for electrical system capacity and the electric utility provider has been engaged.
2. Future project teams should carefully evaluate operational issues at potential sites for electric truck deployments with a special focus on the EVSE interfering with normal business operations and how trucks will be moved/parked for charging.
3. CARB should consider subsidizing or providing incentives for manufacturer testing of advanced electric truck and equipment for performance, durability, and reliability at a nationally recognized testing facility such as TRC before these vehicles or equipment can be sold to customers and/or receive incentive or grant funding so that fleets and end-users are assured the products meet minimum standards for performance.

Chapter 3: USPS Future Intent for Trucks

Maintaining the project

The USPS has stated their intention to continue using the EV Class 4 vehicles, at least until the end of the warranty period (first quarter 2022), which is three (3) years from the date the vehicles were initially placed into service.



EV Class 4 Truck in Service in Fresno (photo courtesy of CALSTART)

Repairs are currently taking place in Stockton to replace the broken single-phase EVSE equipment, which powers the Cummins vehicles. USPS has stated their intentions to move at least one vehicle from the dock area at the Stockton post office and then widening the parking spaces to reduce the possibility of people doing ingress/egress movements running into the charger plugs and putting stress on the charger connectors during charging. The Fresno site has not had any issues with damage to chargers and there are no plans to revise parking at that location.

USPS management is considering getting training for local maintenance staff from both technology providers so the trucks can be maintained properly after the warranty period ends, but nothing formal has been established at the time of this report.

In February 2020, Motiv opened a maintenance facility in Stockton to support their products and this will benefit USPS by reducing maintenance response times, especially at the Stockton post office site.

Further development of EV

USPS has expressed interest in migrating their fleet to EVs, particularly their Class 4 fleet. USPS has 560 of these vehicles in California, and since these vehicles would be eligible for CARB's Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP) funds in California, this could be the first USPS fleet to be migrated to electric propulsion. USPS has nearly 9,000 Class 4s nationwide.

USPS has also been evaluating the electrification of its smaller long-life vehicles (LLV) used to make door-to-door deliveries. However, due to the low mileage driven each day (21-22 miles), it is more difficult to justify the cost of vehicle replacement, particularly when the cost of EVSE installations at local post office sites where these vehicles are based each day is included. As an alternative to the expense of Level 2 chargers for the smaller LLV, USPS has been exploring the use of roof mounted solar film made by Alta Devices which is flexible and can be mounted on uneven surfaces such a roof of vehicles. In addition to the solar roofs, USPS has been considering backing up the solar cells on the vehicle with low cost Level 1 chargers that use 110v outlets instead of larger Level 2 chargers.

All of these actions are still in the early stages of evaluation and planning within the management of USPS in Washington D.C. The lessons from the continued operation of the electric Class 4 trucks in the USPS Zero-Emission Delivery Truck Pilot Commercial Deployment Project will likely influence further deployment of electric trucks within the USPS.

Chapter 4: Project Data

CALSTART was responsible for data collection from the vehicles and chargers for the project, but also relied on the technology providers for assistance with this activity. Data on both Motiv and Cummins vehicles was collected by CALSTART through ViriCiti data loggers. These loggers collected vehicle performance data through the vehicle CAN bus and telematics data through on-board hardware. In validating the ViriCiti data, several parameters of the ViriCiti data were found to be inaccurate and unreliable. Several attempts were made to reconcile the data with help from ViriCiti and the OEM partners but for reasons outside of CALSTART's control, the data was not recoverable and therefore not included in the final analysis. Fortunately, core parameters that were essential in assessing vehicle performance were still able to be collected. These core parameters included: distance traveled, energy consumed, and speed data. Using these core parameters, we could still understand duty cycle characteristics and vehicle efficiency.

In addition to the data being collected by CALSTART, Motiv and Cummins were also independently collecting data from their vehicles either manually or through self-installed data loggers. While no data from the OEMs was used in the final analysis, this data was used to further validate the consistency and reliability of the data. Though CALSTART hoped to collect a wider breadth of data from these vehicles, complications in the data collection process limited what data could be used.

The analysis also included a validation and analysis of internal combustion engine USPS vehicles logged by FleetCarma. Overall, the FleetCarma ICE vehicle data was consistent and reliable.

The following data summary was collected from specific trucks at both demonstration sites for the project. Data collection started April 1, 2019 and continued through March 31, 2020. The data listed in the summary was through February 10, 2020 but reflects the observed trends for the entire time frame of the project.

Data Collection & Analysis

ViriCiti

Ten (10) data loggers were installed on EV Class 4s at the locations below.

City	Manufacturer	USPS #
Stockton	Cummins	8550018
Stockton	Motiv	8550015
Stockton	Motiv	8550016
Fresno	Cummins	8550020
Fresno	Cummins	8550021
Fresno	Cummins	8550023
Fresno	Cummins	8550025
Fresno	Motiv	8550011
Fresno	Motiv	8550012
Fresno	Motiv	8550013

FleetCarma

Six (6) data loggers were installed on various ICE Class 4s to provide a baseline comparison. These were installed on vehicles at the locations below.

City	USPS #	C2 ID
Tracy	6530282	00F0-01A3
Modesto	6530026	00F0-01A7
Modesto	6350029	00F0-0191
Merced	7530710	00F0-01AD
Clovis	7530040	00F0-0202
Fresno	6531168	00F0-019B

Because the baseline trucks were not located at the same facilities as the electric trucks in most cases, the average speed and miles driven per day are only of value to show that electric truck operations could be used at other USPS sites within the San Joaquin Valley.

EVSE Monitoring

EVSE charging data is being collected using EVOlution Electric Vehicle Systems monitoring software at both the Stockton and Fresno locations.

Data Analysis

The report from B&V about the economic viability of adding solar and energy storage at both the Fresno site and Stockton site has concluded there is no economic value in on-site renewables and storage for either site, even with full electrification of the delivery fleet in Stockton. A copy of the findings is attached with this report for more details.

The data collected from the on-board loggers for both the electric and conventional powered trucks is listed below along with observations from the data analysis.

	Miles Driven (mi)	kWh/mi	MPG (e)	Total tailpipe CO2 Emissions (lb.)	Total Fuel Consumed (gal equivalent)	Time Driving (hr.)	Avg. Speed in Service (mi)	Avg. Miles Driven per day in use (mi)
Motiv	8,468.1	1.104	30.5	0.0	277.4	370.0	23.9	39.1
Cummins	17,035.3	1.205	28.0	0.0	609.0	620.8	28.8	46.9
Project Total	25,503.4	1.154	29.2	0.0	886.4	990.8	26.3	43.0
Baseline (ICE) Vehicles	26,133.0	n/a	8.4	78,399.0	3,348.6		10.1	29.2

Methodology:

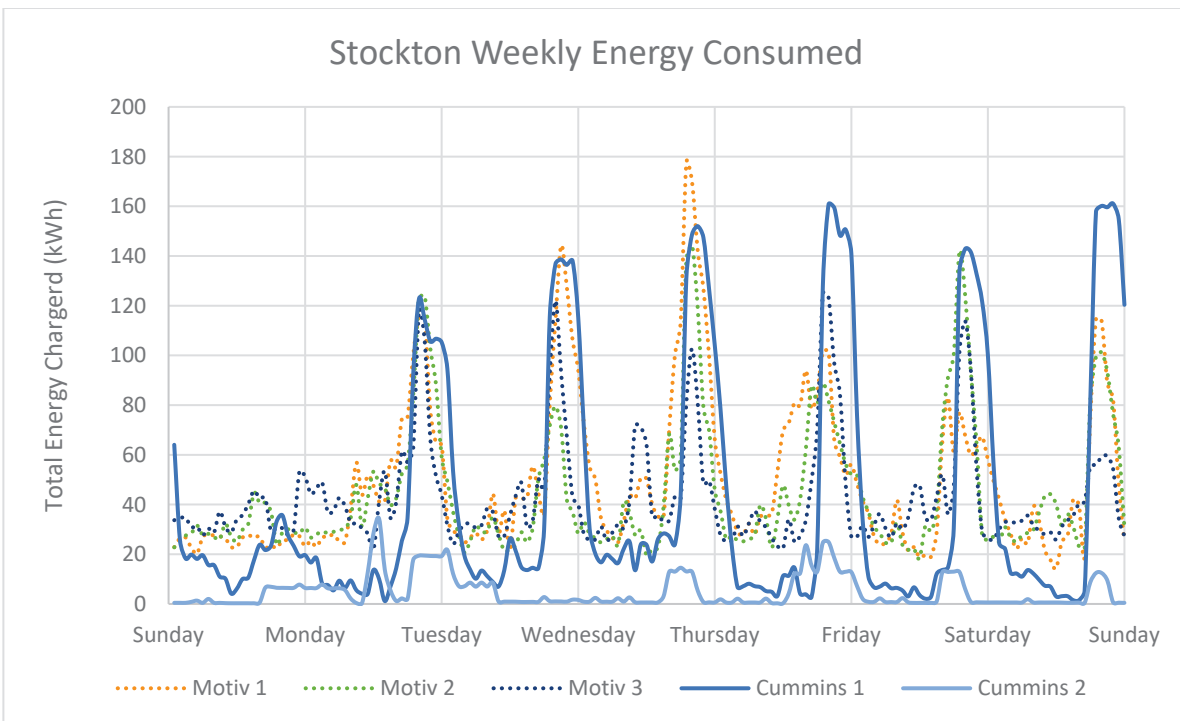
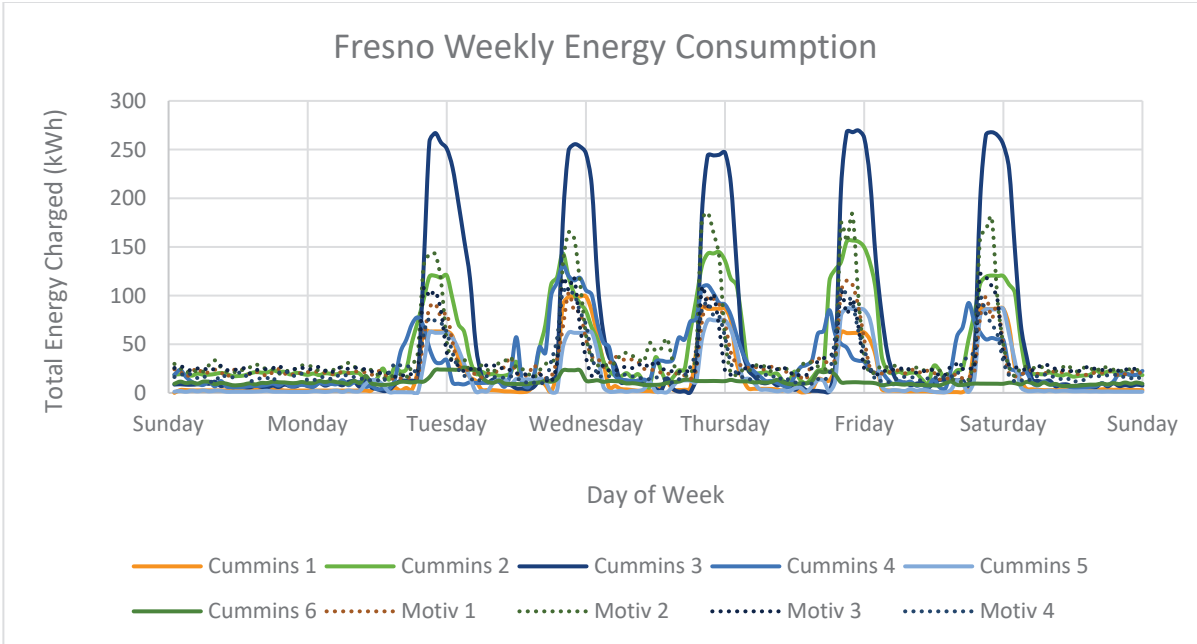
- Miles driven:
 - An in-depth analysis was conducted comparing ViriCiti and Cummins data for miles driven. It was found that ViriCiti data appeared more accurate, so that is what is reported here.
- kWh/mi:
 - An in-depth analysis was conducted comparing ViriCiti and Cummins data for energy consumed driving. This was used to determine kWh/mi. It was found that ViriCiti data appeared more accurate and is reported in the table above.
 - For reference, the Cummins energy data resulted in a kWh/mi of 0.937.
- MPG(e)
 - MPG(e) was calculated based on the following formula from www.mpgtokpl.net that is based on the calculated kWh/mi.
 - Kilowatt hour per 100 miles (kWh/100 miles) is the EPA's way of measuring the efficiency of electric & hybrid vehicles. To keep things simple, EPA provides an equivalent mpg figure for electric & hybrid vehicles (MPGe). The calculator converts kilowatt hour(kWh)/100 miles to MPGe(mpg equivalent).
- Tailpipe CO2 emissions:
 - This is cited in FleetCarma as approx. 3x miles driven for the ICE vehicles used
- Fuel consumed
 - Miles driven / MPG(e)

Observations:

- Cummins vehicles were driven more than 2x as many miles as Motiv.
- Motiv has a slightly lower kWh/mi, meaning they are slightly more efficient.
- Motiv has a slightly higher MPG(e). Both EVs have more than 3x higher MPG(e) than the ICE vehicles.
- The ICE vehicles released over 78,000 lbs. of CO2.
- The EVs appear to be driven at more than 2x the speed of ICE vehicles, but this is likely a result of different data logging companies (ViriCiti for EVs and FleetCarma for ICE vehicles) and the difference in communities where the vehicles operate.
- The EVs appear to be driven further distances per day and this is also likely due to the difference in community locations for the ICE trucks vs. the electric trucks.

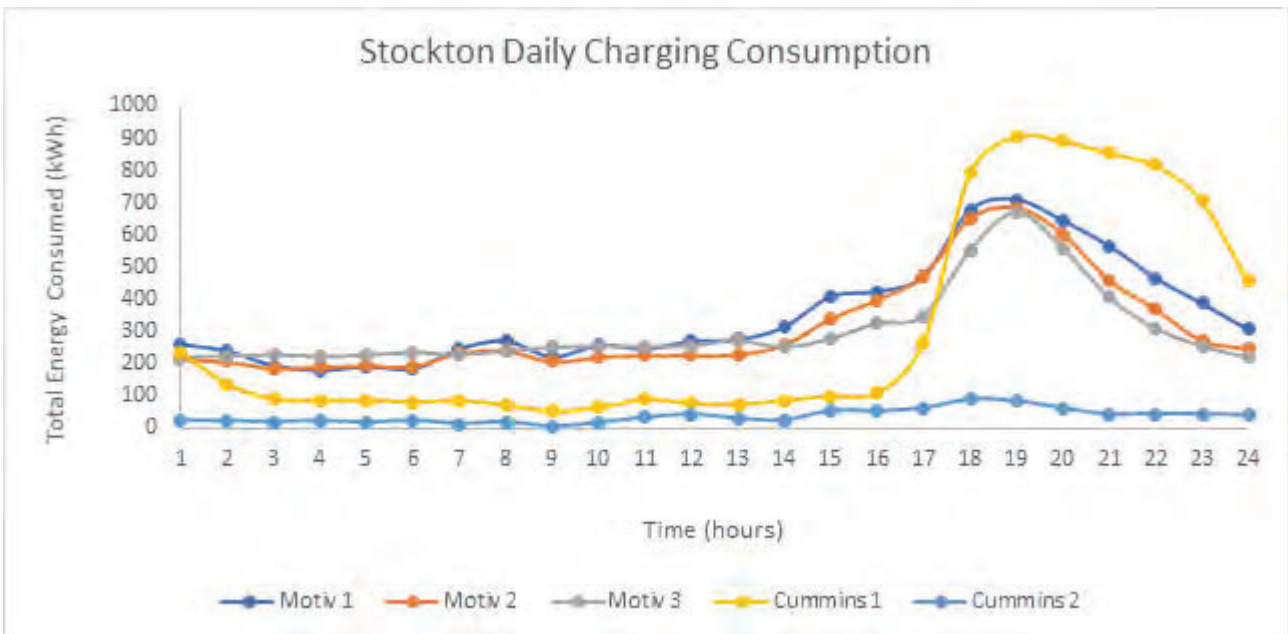
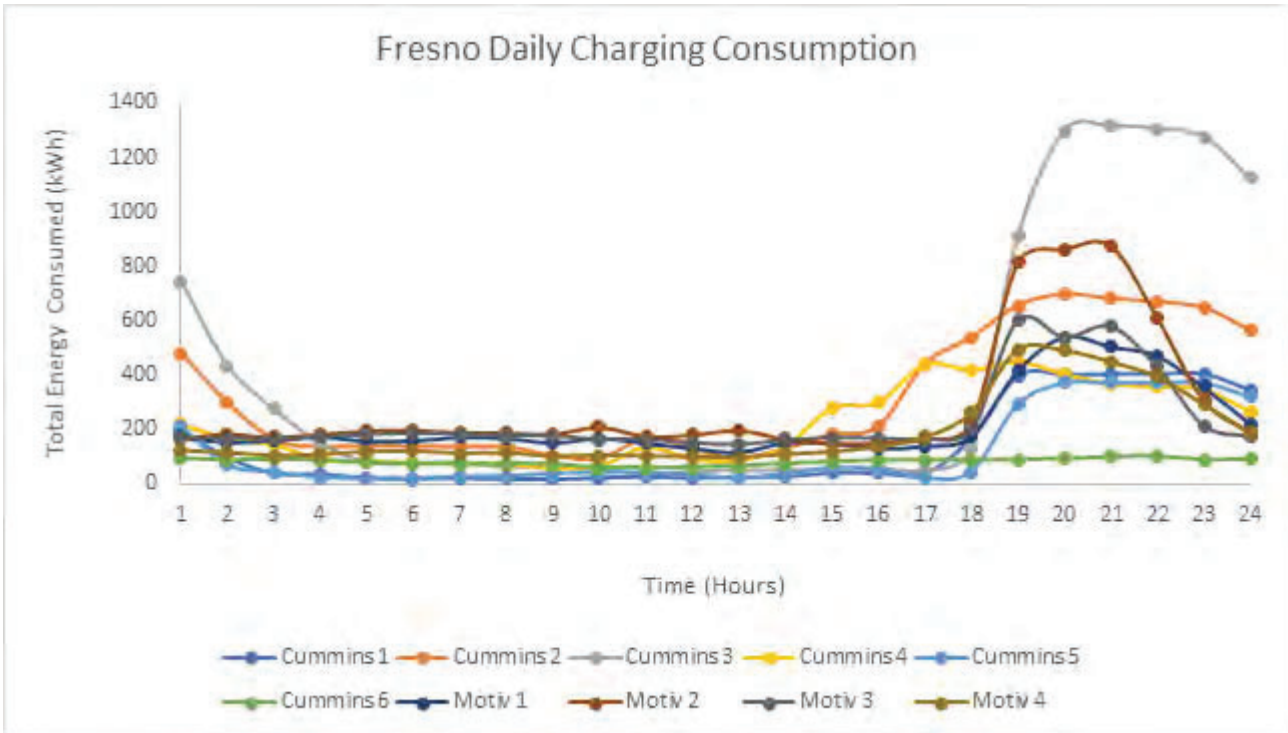
Data from the chargers at each location is listed below along with added observations from reviewing that data. This charger data is interesting in what it shows about the total electricity consumption difference between the Sodium-Nickel battery chemistry used in the Motiv trucks compared with the Li-ion battery chemistry used in the Cummins trucks. (It should be noted that Motiv no longer uses Sodium-Nickel batteries in their products and has converted to using Li-ion chemistry batteries.)

- The Weekly Energy Consumption Graphs sum the total energy consumption per charger for each hour over a 1-week span of the project between 5/1/19 and 1/10/20. For example, all of the energy charged within a 24-hour period on a given Tuesday was summed and represented over a 1 week span. Each vertical line above a day of the week occurs exactly at midnight.



- The weekly energy consumption shows that the major charging sessions occur nightly, beginning at about 6 pm, between Monday night and Tuesday morning – Friday night / Saturday morning.
- Neither Motiv nor Cummins vehicles appear to draw significantly more energy than the other over the span of a week.

The Daily Charging Consumption graphs sum the total energy consumption per charger for each hour of the day between 5/1/19 and 1/10/20. For example, all the energy charged between 24-hour periods each day was aggregated and represented in the charts below for a single day.



- While a bit difficult to see, especially in the Fresno graph, every Motiv vehicle in both Fresno and Stockton consumes more energy during the daytime hours due to the battery chemistry difference. This difference of Motiv drawing more energy than Cummins during the day sums up to approximately 100-200 kWh per hour between the hours of 4 am and 2 pm over the entire span of the analysis (slightly over 8 months). As the B&V analysis indicates, the partial peak hours for

Pacific Gas and Electric Company (PG&E) are from 9 am – 12 pm, and 6 pm – 9 pm. PG&E’s peak hours are from 12 pm – 6 pm. Motiv’s battery composition (Sodium Nickel) leads it to draw more energy during the day due to the need to keep the batteries hot, which is the most expensive hours due to PG&E’s current pricing model.

- Still, the majority of charging for both Motiv and Cummins vehicles occurs between 6 pm – 10 pm, which indicates that vehicles are plugged in usually around 5 or 6 pm at the end of the working day. This is still during partial-peak pricing, and substantial amounts of money could be saved if vehicles could wait until 9 pm to be plugged in and/or the truck charging was controlled through software that only starting the charging when electricity pricing was the lowest.

The tables below represent total energy consumption and mileage for both sites

Stockton

Motiv Charger 1 (kWh)	Motiv Charger 2 (kWh)	Motiv Charger 3 (kWh)	Total Motiv Chargers (kWh)	Motiv Vehicles with Data Loggers	Total Miles Driven (mi)
8381	7519	7260	23160	2	3875

Cummins Charger 1 (kWh)	Cummins Charger 2 (kWh)	Total Cummins Chargers (kWh)	Cummins Vehicles with Data loggers	Total Miles Driven (mi)
7194	858	8052	1	3,989

Fresno

Motiv 1 Charger (kWh)	Motiv 2 Charger (kWh)	Motiv 3 Charger (kWh)	Motiv 4 Charger (kWh)	Total Motiv Chargers (kWh)	Motiv Vehicles with Data Loggers	Total Miles Driven
5,306	6,954	5,578	4,501	22,339	3	4,593

Cummins 1 Charger (kWh)	Cummins 2 Charger (kWh)	Cummins 3 Charger (kWh)	Cummins 4 Charger (kWh)	Cummins 5 Charger (kWh)	Cummins 6 Charger (kWh)	Total Cummins Chargers (kWh)	Cummins Vehicles with Data Loggers	Total Miles Driven (mi)
3,206	7,624	9,720	5,118	2,898	1938	30,504	4	13,046

Total Energy Consumed (kWh)	Motiv (7)	Cummins (8)
	45,499	38,556
Total Miles Driven (mi)	Motiv (5)	Cummins (5)
	8,468	17,035

- These values show us that in total, the battery chemistry in the Motiv trucks consumed more energy while driving less than half as many miles. It is important to note that 5 (or more) of each type of vehicle were deployed with data loggers, so the miles driven can be compared equally. There were in total 8 Cummins vehicles deployed and 7 Motiv vehicles deployed, which directly corresponds to the energy consumed data in kWh. In terms of total energy consumed, we see that Motiv draws more energy despite having 1 less vehicle. Overall, it can be determined that the energy drawn by Motiv vehicles to remain warm due to the Sodium-Nickel battery chemistry draws more energy than the Li-ion battery chemistry in the Cummins vehicles, lowering their efficiency. Operational vehicle efficiency (kWh/mi) in Motiv vehicles was only slightly lower than Cummins (1.1 vs. 1.2), so the battery chemistries performed similarly when the vehicles were in motion. However, when looking at energy consumption in total, the Sodium Nickel battery chemistry appears less efficient / cost effective for the end user than Li-ion. It should be noted that Motiv no longer uses Sodium-Nickel batteries in their products and has converted to using Li-ion chemistry batteries.

Chapter 5: Contractor Listing

	Contractor	Role	Contact	Contact Email	Phone	Address
1	Albright Electric	EVSE Installation	Steve Shuck	steve.shuck@att.net	559-486-1268	2245 E. McKinley Ave, Fresno, CA 93703
2	EVolution Electric Vehicle Systems	EVSE Monitoring	Stuart Irwin	stuart@EVolutionevs.com	248-408-4162	445 Wattles Rd, Bloomfield Hills, MI 48304
3	First Priority Greenfleet	Vehicle maintenance	Robert Lupacchino	rlupacchino@firstpriorityglobal.net	912-596-6864	1627 Army Court, #1, Stockton, CA 95206
4	Clipper Creek	EVSE provider	Will Barrett	will@clippercreek.net	530-887-1674	11850 Kemper Road Suite #E, Auburn, CA 95603
5	Black & Veatch	Solar/Storage Analysis	Paul Stith	stithp@bv.com	913-458-8747	Santa Cruz, CA
6	ViriCiti	Data Loggers	Joel Torr	j.torr@ViriCiti.com	858-213-3506	San Diego, CA
7	Fleet Carma	Data Loggers	Eric Mallia	emallia@fleetcarma.com	519-342-7385	2-60 Northland Dr, Waterloo, ON N2V 2B8 Canada
8	Interstate Engineering Inc.	CAD Engineer	Jeff Graham	jgelect@comcast.net	559-288-1516	1613 E. Golden Valley Way, Fresno, CA 93730

Chapter 6: Appendix

The following surveys were conducted with eight USPS staff members, consisting of four USPS drivers and four employees in USPS management positions. The surveyed individuals were asked to reply to six statements each, which pertain to their experiences with the new electric vehicles. Participants were asked to rate each statement with one of five possible answers: “Strongly Agree”, “Agree”, “Not Sure”, “Disagree”, and “Strongly Disagree”.

USPS-Conducted Driver and Management Survey Summaries

Driver Survey	Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
I prefer driving an electric parcel delivery van	0	0	2	2	0
The electric parcel delivery van is just as CAPABLE as the non-electric parcel delivery van	0	0	0	4	0
The electric parcel delivery van is just as RELIABLE as the non-electric parcel delivery van	0	2	1	1	0
Driving an electric parcel delivery van for work is less stressful for me	0	0	2	2	0
I would like to see our entire fleet be electric-powered	0	3	1	0	0
I have never been stranded by an electric parcel delivery van	2	1	0	0	1

Management Survey	Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
I like having electric parcel delivery vans in my fleet	0	0	0	2	2
The electric parcel delivery van is just as CAPABLE as the non-electric parcel delivery van	0	0	2	1	1
The electric parcel delivery van is just as RELIABLE as the non-electric parcel delivery van	0	0	1	2	1
Maintaining an electric parcel delivery van is less work than a non-electric parcel delivery van	0	1	2	1	0
I would like to see our entire fleet be electric-powered	0	2	0	1	1
I have never had to rescue a stranded electric parcel delivery van driver	1	0	0	2	1

USPS-Conducted Driver and Management Survey Results

Driver Survey:

Participant A

1. I prefer driving an electric parcel delivery van: **Not Sure**
2. The electric parcel delivery van is just as CAPABLE as the non-electric parcel delivery van: **Agree**
3. The electric parcel delivery van is just as RELIABLE as the non-electric parcel delivery van: **Agree**
4. Driving an electric parcel delivery van for work is less stressful for me: **Agree**
5. I would like to see our entire fleet be electric-powered: **Disagree**
6. I have never been stranded by an electric parcel delivery van: **Strongly Disagree**

Participant B

1. I prefer driving an electric parcel delivery van: **Not Sure**
2. The electric parcel delivery van is just as CAPABLE as the non-electric parcel delivery van: **Agree**
3. The electric parcel delivery van is just as RELIABLE as the non-electric parcel delivery van: **Disagree**
4. Driving an electric parcel delivery van for work is less stressful for me: **Not Sure**
5. I would like to see our entire fleet be electric-powered: **Disagree**
6. I have never been stranded by an electric parcel delivery van: **Strongly Disagree**

Participant C

1. I prefer driving an electric parcel delivery van: **Agree**
2. The electric parcel delivery van is just as CAPABLE as the non-electric parcel delivery van: **Agree**
3. The electric parcel delivery van is just as RELIABLE as the non-electric parcel delivery van: **Not Sure**
4. Driving an electric parcel delivery van for work is less stressful for me: **Agree**
5. I would like to see our entire fleet be electric-powered: **Not Sure**
6. I have never been stranded by an electric parcel delivery van: **Disagree**

Participant D

1. I prefer driving an electric parcel delivery van: **Agree**
2. The electric parcel delivery van is just as CAPABLE as the non-electric parcel delivery van: **Agree**
3. The electric parcel delivery van is just as RELIABLE as the non-electric parcel delivery van: **Disagree**
4. Driving an electric parcel delivery van for work is less stressful for me: **Not Sure**
5. I would like to see our entire fleet be electric-powered: **Disagree**
6. I have never been stranded by an electric parcel delivery van: **Strongly Agree**

Management Survey:

Participant A

1. I like having electric parcel delivery vans in my fleet: **Agree**
2. The electric parcel delivery van is just as CAPABLE as the non-electric parcel delivery van: **Not Sure**
3. The electric parcel delivery van is just as RELIABLE as the non-electric parcel delivery van: **Not Sure**
4. Maintaining an electric parcel delivery van is less work than a non-electric parcel delivery van: **Not Sure**
5. I would like to see our entire fleet be electric-powered: **Strongly Agree**
6. I have never had to rescue a stranded electric parcel delivery van driver: **Strongly Disagree**

Participant B

1. I like having electric parcel delivery vans in my fleet: **Agree**
2. The electric parcel delivery van is just as CAPABLE as the non-electric parcel delivery van: **Agree**
3. The electric parcel delivery van is just as RELIABLE as the non-electric parcel delivery van: **Agree**
4. Maintaining an electric parcel delivery van is less work than a non-electric parcel delivery van: **Disagree**
5. I would like to see our entire fleet be electric-powered: **Disagree**
6. I have never had to rescue a stranded electric parcel delivery van driver: **Agree**

Participant C

1. I like having electric parcel delivery vans in my fleet: **Strongly Agree**
2. The electric parcel delivery van is just as CAPABLE as the non-electric parcel delivery van: **Not Sure**
3. The electric parcel delivery van is just as RELIABLE as the non-electric parcel delivery van: **Strongly Agree**
4. Maintaining an electric parcel delivery van is less work than a non-electric parcel delivery van: **Agree**
5. I would like to see our entire fleet be electric-powered: **Agree**
6. I have never had to rescue a stranded electric parcel delivery van driver: **Strongly Agree**

Participant D

1. I like having electric parcel delivery vans in my fleet: **Strongly Agree**
2. The electric parcel delivery van is just as CAPABLE as the non-electric parcel delivery van: **Strongly Agree**
3. The electric parcel delivery van is just as RELIABLE as the non-electric parcel delivery van: **Agree**
4. Maintaining an electric parcel delivery van is less work than a non-electric parcel delivery van: **Not Sure**
5. I would like to see our entire fleet be electric-powered: **Disagree**
6. I have never had to rescue a stranded electric parcel delivery van driver: **Agree**