

Fuel Cell Hybrid Electric Delivery Van Project

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DOE Hydrogen Program

2023 Annual Merit Review and Peer Evaluation Meeting



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Project Goal

Overall Objectives

- **Substantially increase the zero-emission driving range**, thereby increasing the commercial viability of electric drive medium-duty trucks
- **Accelerate the introduction and market penetration** of electric drive transportation technologies to meet the demands of commercial fleet customers shifting towards zero-emission alternatives and **supporting the growth of hydrogen economies at scale**
- **Collect and analyze data from sixteen fuel cell hybrid electric vehicles** to provide the industry with performance, reliability, and cost metrics that will support the continuous development towards fully commercialized medium-duty, zero-emission vehicles

Project Overview

Timeline

Project Start: 07/15/2014
Project End: 02/28/2024

Budget

Total Project Budget: \$ 11,264,505
Total Recipient Share: \$ 8,282,434
Total Federal Share: \$ 2,982,071
Total DOE Funds Spent: \$ 2,598,493*

*through Mar. 2023

Partners

US DOE, CARB, SCAQMD, CEC, SoCalGas: Project Sponsors
UPS: Commercial Fleet Partner and Operator
CTE: Prime Contractor and Project Manager
Cummins, UES, UT-CEM: Subcontractors

Barriers

Technology Validation

A. Lack of Fuel Cell Electric Vehicle Performance and Durability Data

Market Transformation

D. Market uncertainty around the need for hydrogen infrastructure versus timeframe and volume of commercial fuel cell applications
F. Inadequate user experience for many hydrogen and fuel cell applications



Relevance

Overall Objectives

- **Phase 1:** develop a demonstration vehicle in order to prove its viability to project sponsors, commercial fleet partner (UPS), and other stakeholders [\[Barriers A & F\]](#)
- **Phase 2:** build and deploy a pre-commercial volume (15) of the same vehicle for at least 5,000 hours of in-service operation [\[Barriers A & F\]](#)
- Develop an Economic & Market Opportunity Assessment for medium-duty fuel cell hybrid electric trucks [\[Barrier D\]](#)

Current Year Objectives (April 2022 – March 2023)

- Complete Phase 2 vehicle manufacturing of 15 FCEVs
- Stage deployment into UPS service
- Ensure necessary operation and maintenance training
- Begin data collection analysis throughout the two-year demonstration to form the basis for the Economic & Market Opportunity Assessment



Photo: UPS FCEV in line to fuel at Ontario Hydrogen Fueling Station

Relevance – DOE Program Goals

Alignment with DOE Program Goals

- The project promotes commercialization of hydrogen fuel cell vehicles by designing energy storage and drive system for new-builds and conversion kit retrofits, deploying multiple vehicles within the UPS delivery fleet, and utilizing hydrogen fueling infrastructure
- The Fuel Cell Hybrid Electric Delivery Van Project:
 - Increases end-user's experience and knowledge of H₂ fuel cell vehicles
 - Ensures the creation of a commercially viable product by involving UPS in design activity
 - Pushes industry to address need for H₂ infrastructure in medium-duty market



Photo: UPS FCDV in line to fuel at Ontario Hydrogen Fueling Station

Approach – Project Scope



Photo: Phase 1 Vehicle in motion

Phase 1: Convert, Demonstrate, and Validate 1 Vehicle

- Convert existing UPS diesel-powered van to a base electric-drive vehicle [\[out of DOE project scope\]](#)
- Integrate FC, power electronics, hydrogen storage system, and controls
- Train UPS fleet operators and support staff
- Demonstrate and validate in UPS fleet for 6 months

Phase 2: Build & Deploy 15 Vehicles

- UES is responsible for full integration activities, with CEM assistance
- CTE will coordinate training of UPS fleet operators and support staff
- UPS will operate vehicles at multiple distribution centers in California
- 2 years of data collection and project reporting
- Develop an Economic & Market Opportunity Assessment



Photo: Phase 2 fleet at the UPS Facility in Ontario

Approach – Project Milestones

Task	Description	% Complete	Estimated Completion Date
Phase 1 Demonstration			
1	Vehicle Build	100%	Jan. 2019
2	Training and Education	100%	Feb. 2019
3	Demonstration Vehicle Test and Evaluation	100%	Oct. 2019
4	Project Management Phase 1	100%	Oct. 2019
Go / No-Go Decision Point		Completed in Oct. 2019	
Phase 2 Deployment			
5	Vehicle Build	96%	Jan. 2023
6	Training and Education	100%	Mar. 2022
7	Vehicle Test and Evaluation	10%	Jun. 2024
8	Project Management Phase 2	66%	Apr. 2024



Any proposed future work is subject to change based on funding levels.

2022 Accomplishments and Progress – Summary

Continued deployment of Phase 2 Fleet in UPS Service

- ✓ Completed operations training for van drivers, support staff, and first responders over multiple sessions in March 2022.
- ✓ Completed build and shipment of all 15 fuel cell hybrid delivery vans to Ontario, CA.
- ✓ Developed pre-deployment plans around training, support, maintenance, and fueling



Photo: Phase 2 Fuel Cell Delivery Vans at the UPS Facility

Accomplishments and Progress – Build

- ✓ Completed 100-mile drive test for all 15 vehicles and analyzed vehicle performance using the online dashboard
- ✓ Conducted a third-party inspection of vehicle build and validation
- ✓ Improvements and updates:
 - ✓ Added H2 door sensor
 - ✓ Relocated electrical disconnect switch
- ✓ The snapshot below shows the completed build matrix as of March 2023

UES/CTE #	Vehicle Assembly Kits Created	Vehicle Teardown	OP1 Chassis Interface Install	OP2 LVJB	OP3 Hydraulic System	OP4 HVJB	OP5 Hood Lift Install	OP6 AC Junction Boxes	OP7 12V Battery System	OP22 H2 Storage	OP24 Lubrication	OP10 Cooling Install	OP11 OEM PDC Installation	OP12 Craash Sensor Install	OP13 Charger Install	OP14Traction Inverter	OP15 Harness Install
CTE 2	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete
CTE 3	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete
CTE 4	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete
CTE 5	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete
CTE 6	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete
CTE 7	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete
CTE 8	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete
CTE 9	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete
CTE 10	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete
CTE 11	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete
CTE 12	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete
CTE 13	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete
CTE 14	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete
CTE 15	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete
CTE 16	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete

Table: Completed Build Matrix

Accomplishments and Progress – Pre-Deployment



Photo: Fueling vehicle

- ✓ Developed a two-phase vehicle deployment and rollout plan that requires:
 - ✓ 3 trained drivers per vehicle
 - ✓ 1 trained On-Road Supervisor per vehicle
 - ✓ Gate conditions to be met by first 7 vehicles
- ✓ Improved communication protocol with hydrogen fueling station
- ✓ Created fuel cell shutoff function as a method of risk mitigation during hydrogen fueling
- ✓ Refreshed project support and safety documentation in preparation for vehicle deployment
 - ✓ Pre-Trip & Post-Trip Checklist
 - ✓ Certification of Knowledge Transfer
 - ✓ Fueling Instructions

Accomplishments and Progress – Vehicle Deployment

- ✓ Vehicles await confirmation from UPS to begin delivery service
- ✓ Fuel cells achieved maximum power output after extended period of time in storage
 - ✓ Achieved by initially operating fuel cell modules at low power and reducing ramp rate
- ✓ Developed new performance indicators on the online dashboard to track vehicle performance throughout the demonstration

CTE# 14 Performance Data from 9/28/22 in Ontario, CA



Chart: CTE

Responses to 2021* AMR Comments

“It seems much progress has been made since the last Hydrogen Program Annual Merit Review. It is great to see the fuel cell van well received by United Parcel Service (UPS) drivers. Most issues have been addressed, except for the life/durability issues, which will require extended study and testing to evaluate to end-of-life conditions”

- The project team is proud of its continued progress throughout challenges presented outside of project scope. The project has maintained relevance to the deployment of fuel cell medium-duty vehicles in the industry.
- During Phase 2, all collected data will be processed and made available in an interactive dashboard for the Project Team to monitor and analyze the fleet’s performance, including uptime and durability across two years of operation.

Responses to 2021* AMR Comments

“Other organizations such as the Hydrogen Safety Panel and the National Renewable Energy Laboratory (NREL) can both detract from and add to a pilot project such as this. Data collection can add additional hurdles in formatting and user fatigue. The second review of safety may result in constructive support but brings additional project risk and possible cost.”

- The Hydrogen Safety Panel and NREL was involved in the original Functional Hazard Analysis.
- The project team and UPS’s insurance provider, Liberty Mutual, completed a high level review and confirmation of every safety related item onboard the vehicles since the initial design. This effort added significant time to the deployment plan
- Safety is the project’s number 1 priority, and the project team was able to effectively revisit its approach to safety to ensure adherence to relevant codes, standards, and best practices.
- CTE and the team have incorporated data collection requirements from the original NOFO.



Photo: Phase 1 Delivery Van retrofit

Responses to 2021 AMR Comments

“Retrofitting the old chassis vehicles may be an impediment because of certification issues and not being able to take advantage of the latest developments in safety, functionality, weight savings, connectivity, etc.”

“It would be good to know what the ‘fueling station issues’ were and how they were addressed. This can help the industry improve infrastructure for future easier adoption”



Photo: Hydrogen lanes at station in Ontario

- The propulsion system being developed and demonstrated is capable of integration into new chassis with minor modifications. In Phase 2, UES focused on development and documentation of efficient build processes.
- At the onset of the project, the project team took a proactive approach to identifying codes, standards, and certifications that may be affected by the retrofit and ensured that no FMVSS certified systems on the base vehicle would be affected.
- Most of the technical issues occurred at the West Sacramento fueling station. Phase 2 deployment station in Ontario has not experienced technical issues, but has experienced periods of low fuel supply. The project team has established mitigation strategies to prevent operational impacts.

Collaborations and Project Partners



Remaining Barriers and Challenges

Issue – Leadership Turnover

A propane fueled delivery van fire at the UPS facility in Lancaster in April 2022 created a high level of concern surrounding alternative-fueled vehicles

New UPS executives required safety audit and additional review that resulted in significant delays

Resolution

- Safety has always been high priority for this team. The safety process was established at the outset of the project and every stakeholder was involved. However, our entire process and results had to be reviewed and vetted again.
- The project team submitted multiple iterations of a detailed safety report in response.
 - The UPS Safety Report includes facility assessments, documentation of all tests, parts certification, system safety, communication, maintenance, risk mitigation, and first responder plans. Additionally, project team created thorough functional hazards analysis, driver, operator, maintenance, fueling, and first responder manuals, as well as training material and transfer of knowledge certifications.
- Ultimately required approval by UPS Risk Mitigation team and insurance carrier
- Safety audit is impacting both of CTE's FCDV deployment projects with UPS

Remaining Barriers and Challenges

Issue – Utilizing public hydrogen refueling infrastructure prevented a significant number of demonstration days

Phase 1 demonstration utilized multiple fueling sites as the vehicle operated out of multiple UPS facilities

Phase 2 vehicles are ready for in-service operation with UPS before the Ontario station is able to provide fuel

Resolution

- Worked cooperatively with station operations staff to identify potential technical issues early and mitigate impacts to fuel availability
- Adjusted operational strategy to refuel the demonstration vehicle at the end of a shift so that the vehicle would not go out for service and be unable to fuel, thereby unable to complete its service
- Regular communication with Ontario station management and provided first Phase 2 vehicle to support technical troubleshooting and overall commissioning procedure

Proposed Future Work (Next Year)

Task 7 – Phase 2 Vehicle Test and Evaluation

Provide vehicle operational support [1Q 2023 – 4Q 2024]

Conduct in-service data collection [1Q 2023 – 4Q 2024]

Task 8 – Phase 2 Project Management

Monitor budget, schedule, risk, and mitigation [1Q 2022 – 4Q 2024]

Summary

Objective: Substantially increase the zero-emission driving range, thereby reducing emissions, and increasing the commercial viability of electric drive medium-duty trucks.

Relevance: Fuel cell hybrid electric delivery van design, build, validation, deployment, and data collection project in the UPS fleet environment. Performance objectives include 125-mile range and over 95% of UPS routes.

Approach: Two-phase project, with go/no go decision. Phase 1 includes the design, build, validation, and demonstration of one vehicle. Phase 2 includes the build, deployment, and data collection of 15 additional vehicles.

Accomplishments: Successfully navigated demonstration delays, created a deployment plan for Phase 2 vehicles, commissioned and delivered full fleet to Ontario facility, and improved data analytics dashboard for tracking vehicle performance.

Collaborations: Full project team dedicated to the commercialization of viable technology, including a world-class and internationally recognized commercial fleet operator in UPS. Strong set of project sponsors leveraging federal, state, and private funding.



Photo: Delivery of Phase 2 Van