U.S. DEPARTMENT OF
ENERGY

Office of
ENERGY EFFICIENCY &
RENEWABLE ENERGY

Technology Integration

2023 Annual Progress Report

Vehicle Technologies Office

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Disclaimer

Acknowledgements

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Acronyms

AAR	Association of American Railroads
ACEP	Alaska Center for Energy and Power
ACES	Automated, Connected, Efficient, and Shared
ACES	ASRC Consulting & Environmental Services, LLC
AFDC	Alternative Fuels Data Center
AFLEET Tool	Alternative Fuel Life-Cycle Environmental and Economic Transportation Tool
AFPR	Alternative Fuel Price Report
AFV	Alternative Fuel Vehicle
AHJ	Authority Having Jurisdiction
ALA	American Lung Association
AMP	Affordable Mobility Platform
AMR	Annual Merit Review
ANGI	ANGI Energy Systems LLC
ANL	Argonne National Laboratory
API	Application Programming Interface
AVTCs	Advanced Vehicle Technology Competition
BEV	Battery Electric Vehicle
BIPOC	Black, Indigenous, and people of color
BOD	Board of Directors
BRT	Bus Rapid Transit
BSSD	Blue Springs School District
BY	Budget Year
CAD	Computer Aided Design
CAN	Controller Area Network
CARB	California Air Resources Board
CBO	Community-based organization
CBO	Community-based organizations
CCC	Clean Cities Coalitions
CFI	Charging and Fueling Infrastructure Discretionary Grant Program
CFO	Clean Fuels Ohio
CNG	Compressed Natural Gas
CO2	Carbon Dioxide
COOL EVs	Cold-Weather Operation, Observation and Learning with Electric Vehicles
CRuSE	Clean Rural Shared Electric Mobility Project
CSE	Center for Sustainable Energy
CSI	City Seniors, Inc.
CTE	Center for Transportation and the Environment
CWCC	Columbia-Willamette Clean Cities Coalition
DACs	Disadvantaged Communities
DAS	Data Acquisition Systems
DCC	Drive Clean Colorado
DCFC	Direct current fast chargers
DEI	Diversity, Equity, and Inclusion

DER	Distributed Energy Resources
DERA	Diesel Emissions Reduction Act
DERST	Distributed Energy Resources Safety Training
DEUSA	DRIVE Electric USA
DGE	Diesel Gallon Equivalent
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
DTE	distance-to-empty
EEJ	Energy and Environmental Justice
EEMS	Energy Efficient Mobility Systems
EERE	Office of Energy Efficiency and Renewable Energy
EIA	Energy Information Agency
EISA	Energy Independence and Security Act
EMPOWER	Equitable Mobility Powering Opportunities for Workplace Electrification
EMS	Emergency Medical Service
EPA	U.S. Environmental Protection Agency
EPAct	Energy Policy Act
ESB	Electric School Bus
ESS	Energy Storage Systems
ETCF	East Tennessee Clean Fuels
eTrucks	battery-electric trucks
EV	Electric vehicles
EVI-Pro Lite	Electric Vehicle Infrastructure Projection
EVSE	Electric vehicle supply equipment
FEA	Finite Elements Analysis
FEI	Fuel Economy Information
FEMP	Federal Energy Management Program
FOA	Funding Opportunity Announcement
FRA	Federal Railroad Administration
FY	Fiscal Year
GCKS	City of Garden City, Kansas
GEM	Geospatial Energy Mapper
GHG	Greenhouse Gas
GREET	Greenhouse gases, Regulated Emissions, and Energy use in Transportation
GTSE	Green Transportation Summit and Expo
GVSD	Grain Valley School District
H_2	Hydrogen
HBCU	Historically Black Colleges and Universities
HD	Heavy-Duty
HDV	Heavy-Duty Vehicle
HEV	Hybrid Electric Vehicle
IACT	Illinois Alliance for Clean Transportation
IRB	Institutional Review Board
IRS	Internal Revenue Service
JCCC	Johnson County Community College

KC	Kansas City
KCI	Kansas City International
KCM	King County Metro
KCMO	City of Kansas City, Missouri
KDOT	Kansas Department of Transportation
KDOT	Kansas Department of Transportation
KPIs	Key Performance Indicators
KU	Kansas University
kW	kilowatt
kWh	Kilowatt-hour
LEM	Lightning eMotors
LMS	Learning management system
MC3	Minnesota Clean Cities Coalition
MEC	Metropolitan Energy Center
MEP	Mobility Energy Productivity
mph	Miles per hour
MPOs	Metropolitan planning organizations
MST	Missouri University of Science and Technology
MUD	Multi-Unit Dwellings
MY	Model Year
NAFTC	National Alternative Fuels Training Consortium
NAFTD	North American Fire Training Directors
NCSL	National Conference of State Legislatures
NEPA	National Environmental Policy Act
NESCAUM	Northeast States for Coordinated Air Use Management
NETL	National Energy Technology Laboratory
NEV	Neighborhood Electric Vehicle
NEVI	National Electric Vehicle Infrastructure
NFPA	National Fire Protection Association
NGO	Nongovernmental Organizations
NGVs	Natural gas vehicles
NGVTF	National Gas Vehicle Technology Forum
NHTSA	National Highway Traffic Safety Administration
NOx	Nitrogen oxides
NREL	National Renewable Energy Laboratory
NSF	National Science Foundation
NSYSSC	Northside Youth and Senior Service Center
NYSERDA	New York State Energy Research & Development Authority
OCPP	Open Charge Point Protocol
ODT	On-Demand Transit
OEM	Original Equipment Manufacturer
OpenPATH	Open Platform for Agile Trip Heuristics
ORNL	Oak Ridge National Laboratory
PERC	Propane Education & Research Council
PEV	Plug-in Electric Vehicle

PI	Principal Investigator
PM	Particulate matter
PMP	Project Management Plan
PMT	Passenger Miles Traveled
PSC	Public Service Commission
PSU	Penn State University
PV	Photovoltaics
RBE	Roads, Bridges, and Engineering Department
RD	Renewable Diesel
RFP	Request for Proposals
RFS	Renewable Fuel Standards
RIN	Renewable Identification Number
RNG	Renewable natural gas
SAFP	State and Alternative Fuel Provider
SDOT	Seattle Department of Transportation
SEPA	Smart Electric Power Alliance
SiLVERS	St. Louis Vehicle Electrification Rides for Seniors
SLCC	St. Louis Regional Clean Cities
SLCFP	Southeast Louisiana Clean Fuels Partnership
SME	Subject Matter Expert
SOPO	Statement of Project Objectives
SRST	Standing Rock Sioux Tribe
ST	Sound Transit
SUVs	Sport utility vehicles
SWS	Department of Solid Waste Services
TCO	Total cost of ownership
TI	Technology Integration
TNC	Transportation Network Company
TPSS	Traction Power Substations
TRC	The Routing Company
TRS	Technical Response Service
TTC	Transportation Technology Center
TTU	Tennessee Technological University
UL	Underwriters Laboratory
ULSD	Ultra-low-sulfur diesel
UNOH	University of Northwestern Ohio
USPS	United States Postal Service
UT Austin	The University of Texas at Austin
UTV	Utility Task Vehicle
UTV	utility task vehicle
VMRS	Vehicle Maintenance Reporting Standards
VMT	Vehicle Miles Traveled
VTO	Vehicle Technologies Office
WCRC	Workplace Charging Resource Center
WPC	Workplace Charging

WVU	West Virginia University
ZEFF	Zero Emission Freight Future

Executive Summary

The 2023 Technology Integration Annual Progress Report covers 47 multi-year projects funded by the Vehicle Technologies Office. The report includes information on competitively awarded projects, ranging from electric school bus demonstrations to rural electric mobility projects to first/last mile transit solutions.

It also includes projects conducted by several of the Vehicle Technologies Office's (VTO) national laboratory partners, Argonne National Laboratory, Oak Ridge National Laboratory, and the National Renewable Energy Laboratory. These projects range from a Technical Assistance project for business, industry, government, and individuals, to the EcoCAR Advanced Vehicle Technology Competition, and the Fuel Economy Information Project.

The projects involve partnerships between private industry, the public sector and, in many cases, non-profit organizations, and incorporate an educational component designed to enable the sharing of best practices and lessons learned. Data collected from these projects is used to inform the future direction of VTO-funded research.

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Vehicle Technologies Office Overview

Vehicles move our national economy. Each year in the United States, vehicles transport 18 billion tons of freight—about $55 billion worth of goods each day[1]—and move people more than 3 trillion vehicle-miles.[2] Growing our economy requires transportation, and transportation requires energy. The transportation sector accounts for approximately 27% of total U.S. energy needs[3] and the average U.S. household spends over 15% of its total family expenditures on transportation,[4] making it, as a percentage of spending, the most costly personal expenditure after housing. Transportation is critical to the overall economy, from the movement of goods to providing access to jobs, education, and healthcare.

The transportation sector has historically relied heavily on petroleum, which supports over 90% of the sector's energy needs today,[5] and, as a result, surpassed electricity generation to become the largest source of CO_2 emissions in the country.[6] The Vehicle Technologies Office (VTO) will play a leading role in decarbonizing the transportation sector and address the climate crisis by driving innovation and deploying clean transportation technologies, all while maintaining transportation service quality and safety.

VTO funds research, development, demonstration, and deployment (RDD&D) of new, efficient, and clean mobility options that are affordable for all Americans. VTO leverages the unique capabilities and world-class expertise of the National Laboratory system to develop new innovations in vehicle technologies, including: advanced battery technologies; advanced materials for lighter-weight vehicle structures and better powertrains; energy-efficient mobility technologies (including automated and connected vehicles as well as innovations in efficiency-enhancing connected infrastructure); innovative powertrains to reduce greenhouse gas (GHG) and criteria emissions from hard to decarbonize off-road, maritime, rail, and aviation sectors; and technology integration that helps demonstrate and deploy new technology at the community level. Across these technology areas and in partnership with industry, VTO has established aggressive technology targets to focus RDD&D efforts and ensure there are pathways for technology transfer of federally supported innovations into commercial applications.

VTO is uniquely positioned to accelerate sustainable transportation technologies due to strategic public–private research partnerships with industry (e.g., U.S. DRIVE, 21st Century Truck Partnership) that leverage relevant expertise. These partnerships prevent duplication of effort, focus DOE research on critical RDD&D barriers, and accelerate progress. Working closely and in collaboration with the Office of Energy Efficiency and Renewable Energy's Bioenergy Technologies and Hydrogen and Fuel Cell Technologies Offices, VTO advances technologies that assure affordable, reliable mobility solutions for people and goods across all economic and social groups; enable and support competitiveness for industry and the economy/workforce; and address local air quality and use of water, land, and domestic resources.

Annual Progress Report

As shown in the organization chart (below), VTO is organized by technology area: Batteries R&D; Electrification R&D; Materials Technology R&D; Decarbonization of Off-Road, Rail, Marine, and Aviation; Energy Efficient Mobility Systems; Technology Integration; and Analysis. Each year, VTO's technology areas prepare an Annual Progress Report (APR) that details progress and accomplishments during the fiscal year. VTO is pleased to submit this APR for Fiscal Year (FY) 2023. The APR presents descriptions of each active project in FY 2023, including funding, objectives, approach, results, and conclusions.

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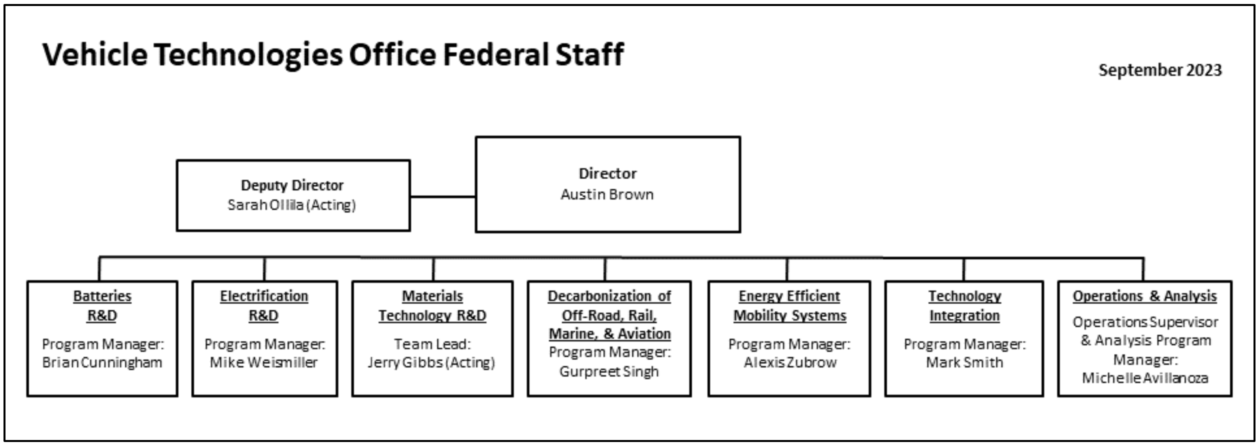
[1] Bureau of Transportation Statistics, DOT, Transportation Statistics Annual Report 2020, Table 4-1, https://www.bts.gov/tsar.
[2] Davis, Stacy C, and Robert G Boundy. Transportation Energy Data Book: Edition 40. Oak Ridge, TN: Oak Ridge National Laboratory 2022. https://doi.org/10.2172/1878695. . Table 3.09 Shares of Highway Vehicle-Miles Traveled by Vehicle Type, 1970-2019.
[3] Ibid. Table 2.02 U.S. Consumption of Total Energy by End-use Sector, 1950-2021.
[4] Ibid. Table 11.1 Average Annual Expenditures of Households by Income, 2020.
[5] Ibid. Table 2.03 Distribution of Energy Consumption by Source and Sector, 1973 and 2021.
[6] Environmental Protection Agency, Draft U.S. Inventory of Greenhouse Gas Emissions and Sinks, 1990-2019, Table 2-11. Electric Power-Related Greenhouse Gas Emissions and Table 2-13. Transportation-Related Greenhouse Gas Emissions.

Organization Chart



Technology Integration Program Overview

Introduction

VTO's Technology Integration Program supports a broad technology portfolio that includes alternative fuels, energy efficient mobility systems and technologies, and other efficient advanced technologies that can reduce transportation energy costs for businesses and consumers. The program provides objective, unbiased data and real-world lessons learned to inform future research needs and support local decision making. It also includes projects to disseminate data, information, and insight, as well as online tools and technology assistance to cities and regions working to implement alternative fuels and energy efficient mobility technologies and systems.

Goals

The Technology Integration Program’s goals are to strengthen national security through fuel diversity and the use of domestic fuel sources, reduce transportation energy costs for businesses and consumers, and enable energy resiliency with affordable alternatives to conventional fuels that may face unusually high demand in emergency situations.

Program Organization Matrix

The Technology Integration Program’s activities can be broken out into several distinct areas:

Core Activities

- **Clean Cities and Communities:** Clean Cities and Communities is a U.S. Department of Energy partnership within the VTO Technology Integration (TI) Program. More than 75 DOE-designated Clean Cities and Communities coalitions work locally in urban, suburban, and rural communities to strengthen the nation’s environment, energy security, and economic prosperity. Coalitions deploy affordable, efficient, and clean transportation fuels; energy efficient mobility systems; and other fuel-saving technologies and practices.

- **Information and Tools:** TI publishes the Fuel Economy Guide and manages the fueleconomy.gov website, which serve as the official U.S. government source for accurate, up-to-date, and useful vehicle fuel economy information for both new and used vehicles. TI also manages the Alternative Fuels Data Center (AFDC) website (AFDC.energy.gov) which provides information and data on alternative and renewable fuels, advanced vehicles, fuel-saving strategies, and emerging transportation technologies.

- **Technical Assistance:** Clean Cities and Communities coalitions provide stakeholders with an entry point for accessing broader VTO-funded technical assistance. Through Clean Cities and Communities coalitions, the Technical Response Service, DOE national laboratories, and on-call subject matter experts, communities have robust access to technical assistance. TI provides technical assistance to a broad range of stakeholders to help fleets deploy alternative fuels, advanced vehicles, and fuel-saving measures. Technical assistance can be both proactive and reactive, either stepping in during the project planning phase or helping solve a problem during or after implementation. The easy access to technical assistance for small or large efforts makes for timely problem solving. The lessons from these activities are shared across coalitions to inform future projects.

- **Training, Outreach, and Partnerships:** Through analysis, tools, and educational resources developed at DOE’s national laboratories, TI provides training and technical capabilities to coalitions and uses a suite of communication approaches to keep the coalitions’ staff connected and learning from each other. TI has established strong partnerships nationwide with numerous industry and place-based associations and their members, large national fleets, OEMs, and other Federal agencies. These partnerships have resulted in robust collaboration with these stakeholders. The key to TI success is working with these groups to understand their goals and challenges and to identify which of those are appropriate for TI to address. This transparent approach leads to greater success both locally and nationally.

- **Financial Assistance**: VTO has funded over 675 TI projects and distributed over $570 million since 1993. These project awards contribute to advancing affordable, domestic transportation fuels, energy efficient mobility systems, and other fuel-saving technologies and practices.

Advanced Vehicle Technology Competitions

For more than 25 years, the Vehicle Technologies Office has sponsored advanced vehicle technology competitions (AVTCs) in partnership with the North American auto industry to educate and develop the next generation of automotive engineers. VTO's advanced vehicle technology competitions provide hands-on, real-world experience, and focus on science, technology, engineering, and math, to support the development of a workforce trained in advanced vehicle technologies.

Launched in 2022, the EcoCAR EV Challenge and the Battery Workforce Challenge are the latest iteration of the advanced vehicle technology competitions. The EcoCAR EV Challenge challenges 15 teams from North American universities to meet the decarbonization needs of the automotive industry by applying automation and connectivity technologies to state-of-the-art battery-electric vehicle platforms. These teams are tasked to incorporate innovative ideas, solve complex engineering challenges, and apply the latest cutting-edge technologies. Teams have four years (2022-2026) to complete the work.

Also launched in 2022, the Battery Workforce Challenge Program was tasked with developing and releasing a Request for Proposals in winter 2023 to solicit universities to join a new AVTC, the Battery Workforce Challenge Competition, co-headline sponsored by DOE and Stellantis, and to launch the competition in Fall 2023.

Alternative Fuels Regulatory Activity

The Alternative Fuels Regulatory activity provides technical and analytical support for the implementation of federal legislation related to the deployment of alternative fuels and fuel-efficient fleet vehicles. Relevant legislation includes the Energy Policy Act (EPAct) of 1992, EPAct 2005, the Energy Conservation Reauthorization Act of 1998, the Energy Independence and Security Act (EISA) of 2007, and other amendments to EPAct.

EPAct regulated fleets include State & Alternative Fuel Provider Fleets and Federal Fleets (managed by the Federal Energy Management Program).

I Alternative Fuel Vehicle Initiatives

I.1 Accelerating Alternative Fuel Adoption in Mid-America (Metropolitan Energy Center)

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Start Date: October 1, 2017 End Date: September 30, 2023
Project Funding: $7,630,417 DOE share: $3,803,793 Non-DOE share: $3,826,624

Project Introduction

The goal of this project is to expand the use of alternative fuels and fueling infrastructure in Kansas and Missouri. In addition to supporting new and expanded fleet adoptions of alternative fuels, the project team plans to increase access to alternative fuels along major travel corridors. There are significant gaps in alternative fueling infrastructure along the I-70, I-29, and US-400 corridors in Kansas. I-70 and I-29 are major shipping corridors, and US-400 is in the middle of the Beef Belt. Insufficient fueling infrastructure is inhibiting alternative fuel adoption throughout the Midwest. The project team continues to promote projects and education that support biodiesel, compressed natural gas (CNG), and electric vehicles (EVs).

Objectives

The project's objectives are to establish alternative fuel options with EV charging, biodiesel and CNG corridors throughout the state of Kansas; expand access to gaseous fuels and EV infrastructure in Kansas and Missouri; and reduce greenhouse gas emissions by converting diesel and gasoline-powered vehicles to alternative fuels.

Approach

Metropolitan Energy Center (MEC) facilitates partnerships between local governments, fleets, and other local stakeholders; assists project stakeholders with resource development and change management; provides training and technical support; and creates accountability and rapport among our stakeholders and project partners. Grant subrecipients include the City of Kansas City, Missouri; Garden City, Kansas; El Dorado, Kansas; the Grain Valley School District in Missouri; Kansas City International Airport; University of Kansas; 24/7 Travel Stores; the City of Olathe; and DS Bus Lines. DOE funding covers 45% of the incremental costs of purchasing alternative fuel vehicles, and 45% of total costs of purchase and installation of fueling infrastructure; the remaining 55% is paid for by the grant subrecipients.

MEC's relationship management approach involves project coordinators working directly with assigned subrecipients as single points of contact and fostering a consultative relationship that allows us to connect subrecipients with resources and prospective vendors, thus generating public-private partnerships.

Using MEC's guidance and their internal guidelines and policies, subrecipients are responsible for sourcing and implementing their own alternative fuel projects with comprehensive tracking and reporting to MEC. Through the course of project implementation, each subrecipient also hosts an alternative fuel workshop, which serves many functions. Workshops educate myriad stakeholders, build community support for the projects, and provide opportunities to develop relationships and engender additional AFV adoption projects.

Results

COVID-19-related shelter-in-place orders resulted in huge reductions in tax revenue for municipal agencies and reduced travel volume, which substantially impacted cash-on-hand for potential for-profit subrecipients that were considering public-access fueling projects on the corridors. While the pandemic impeded the speed with which many of the project partners were able to proceed, the project team was able to make a positive impact while navigating through it and was able to adapt in many areas to meet the needs of the sub-recipients, including no-cost time extensions to enable the completion of critical corridor installations.

Grain Valley School District (GVSD): Grain Valley School District's (GVSD) construction project was completed in 2018, and they are now in the tracking and performance phase of the project. Leftover funding allowed for the addition of two new propane special needs lift buses in 2021, bringing the fleet to 23 propane buses out of 49 total buses. MEC published a Propane School Bus Fleet Case Study on the Grain Valley School District in late 2020, highlighting the district's real-world experiences integrating 21 propane buses into the fleet and discussing how they worked with Clean Cities throughout the entire process. Aside from continuing fuel and fleet tracking, this subproject is now essentially completed.

The City of Garden City, Kansas (GCKS) received and deployed two CNG garbage trucks with Cummins 8.9L engines in 2019 and two in 2020 with Cummins 11.9L engines. The city is now in the tracking and performance phase of the project. A goal of this project was to reduce the noise pollution of trash trucks running their routes. This goal has been accomplished by switching to CNG trucks, as they run quieter. Another benefit of CNG is avoiding diesel gelling in extreme cold. Garden City had hoped to save money by using CNG, but diesel prices remained low, so they did not see the savings they expected. One problem with the 2019 deployment is that the vehicles have insufficient power, creating issues getting in and out of the landfill with the trucks when the ground is wet or snowy. For the 2020 trucks, they purchased larger engines, and this seems to have solved the power problems at the landfill. Garden City reported that they did not experience this issue with diesel trucks. Another issue reported by the fleet is lower than expected miles per gallon for the CNG trucks. The fleet reported that they achieved their goal to reduce emissions but did not achieve their goal of financial savings.

Kansas City International (KCI) Airport: MEC staff is finalizing a deployment guide focused on the electrification of airport fleets. The goal of the guide is to help airports plan, deploy, and manage EVs in their fleets and future-proof their infrastructure to ensure there is electrical capacity on site for future EV deployments. In addition to interviewing KCI Airport (KCI) staff, reviewing case studies, and attending informational webinars, MEC interviewed project stakeholders, as well as alternative fuel stakeholders across the country, including fleet managers, utilities, representatives from EV bus manufacturers, Clean Cities Directors, telematics experts, and EV consultancies. The airport installed direct current fast charger (DCFC) stations in the fourth quarter of 2017, deployed 3 CNG shuttles in the first quarter of 2019 and replaced other CNG vehicles with four EVs in the third quarter of 2020. In FY22, the airport deployed four additional CNG vehicles.

At the beginning of this project, KCI was fielding a 100% CNG fleet of 33 shuttles and was planning a move to near 100% electric shuttles. The electric shuttles were significantly more expensive than the CNG shuttles, however, and KCI has since determined it wants to maintain about 50% CNG for the time-being and is reducing its fleet size in line with an airport redesign. KCI plans to install additional inductive charging electric vehicle supply equipment (EVSE) outside the new parking garage, in front of the new terminal, and deploy additional EV buses to expand the airport's electrification efforts in light of new city ordinances and objectives to promote EVs and sustainability in the city's fleet. The plan is for the shuttle buses to use inductive charging while they are loading and unloading passengers. KCI explored the possibility of retrofitting the existing EV buses previously deployed under this project so that they can also use the new inductive charging, or wireless charging parking pads; however, this proved to be cost-prohibitive.

The City of Kansas City, Missouri (KCMO) has completed deployment of all CNG and electric vehicles and infrastructure. The city deployed 16 new CNG trucks in 2019 and the remaining 7 CNG trucks in 2021. In 2020, KCMO deployed 10 electric sedans and charging infrastructure. The chargers and seven of the sedans are assigned to Neighborhood and Housing Services. The first three sedans are operating at different locations and will continue to use wall outlets to charge when not in use. Two have been deployed to Water Services and one to General Services. All sedans are equipped with telematics software. Feedback from KCMO has been very positive so far. The electric sedans' range of 280 miles is high enough that the units can sufficiently charge for their duty cycle by plugging into a 110-volt outlet overnight and during the weekends. KCMO's drivers report that they appreciate the quieter engine, roomy interior, and electric display screen. With these deployments now completed, KCMO's project is essentially complete, except for continued tracking and reporting for the remainder of the grant project period.

24-7 Travel Stores operates 10 retail and truck stop fueling locations on I-70 and I-35 spurs in Kansas. Due to market forces suppressing interest in new CNG installations, and development partners having pulled out of an installation agreement, 24/7 Travel Stores elected to pursue DCFC and biodiesel in five or more stores, instead of installing two CNG stations as originally planned. MEC and DOE worked with them to finalize a new plan, culminating in the first biodiesel installation at one of their two Salina, Kansas locations in 2020. A small terminal on site feeds that station and provides truckloads of blended biodiesel fuel to other 24-7 Travel Store locations. 24/7 successfully supplied seven of their locations (N 9th Salina, West Crawford Salina, Russell, WaKeeney, Abilene, McPherson, and Maple Hill) with biodiesel blends during 2021. 24/7 has installed or plans to install DCFC at 4 locations (McPherson, Goodland, Colby, and Russell).

To support DCFC development by 24-7 and other fuel retailers, a group of stakeholders led by the state Petroleum Marketers Association lobbied the Kansas legislature to consider a bill that enables private companies to charge customers on a kWh basis in the state of Kansas. MEC provided subject matter input as requested, but MEC's primary role is to advocate to the utility commission (Kansas Corporation Commission) and the utility ratepayer board (Citizens' Utility Ratepayer Board). This legislation was reintroduced when the new legislature reconvened in January 2021, and it was passed and signed by the governor.

Construction and deployment were completed at the McPherson DCFC site with two public 100kW stations installed in March 2021. See Figure I.1.1. Each unit supports one car charging at 100 KW (or the car's limitation) or two cars charging at 50 KW (or the cars' limitations). It sits on the I-135 spur, which is a major corridor between Wichita and Salina with multiple commuting populations in between. 24-7 held a ribbon-cutting ceremony in 2021 with Kansas Department of Transportation (KDOT) and McPherson Chamber of Commerce participating. Attendees included staff from U.S. Senator Marshall's office. Also in 2021, 24-7 completed construction on the new Goodland, Kansas, store. There is now a 12,000–gallon biodiesel tank and inline blender to supply retail biodiesel blends to 24-7's western stores, along with DCFC chargers.

Throughout 2021, 24-7 continued to experience supply chain delays as a result of increased tariffs and supply shortages due to the COVID-19 pandemic. As a result, installations at the Colby and Russell sites were delayed. In 2022, 24-7 worked on getting timelines from its suppliers but faced difficulties due to uncertainties over pricing and availability. This ongoing delay was considered a project risk, since our deadline to complete final installations was prior to the end of September 2022. MEC submitted and received an extension request from DOE in late 2022 to continue 24-7's work in Colby. The equipment has been delivered and work at the Colby site is in progress. 24-7 hopes to complete their work in Colby ahead of schedule, ideally in first quarter 2023. This is a critical corridor location, since there are no other biodiesel fueling stations between Wakeeney, Kansas, and Denver, Colorado along I-70, a distance of approximately 300 miles. Currently, there is only one other non-Tesla charging location in Colby, Kansas, and the next closest charging station is in Goodland, Kansas or Hays, KS, with a distance of almost 150 miles between them.

Winter weather is a challenge for biodiesel blends, as biodiesel gels at significantly higher temperatures than ultra-low-sulfur diesel (ULSD). In February 2021, Kansas experienced lows that haven't been reached in decades. The inline blender at the Salina location allows 24-7 to stop blending in biodiesel instantaneously, but inventory must be rotated to reduce the blend at splash blended sites; 24-7 was able to stop splash blending early enough to rotate in enough straight ULSD, #1 ULSD, and anti-gel treatment to avoid any gelling. 24-7 was one of few retailers in Kansas that managed through the cold front with no onsite gelling and minimal customer complaint. Their independent lab testing along with the organization's experience were key to managing the event. To date, 24-7 reports that the biodiesel side of their business has been profitable. At one point the price of soybeans rose high enough that the price for biodiesel was forecast to surpass that for diesel, which could have affected the blend ratio. In reality, the price of diesel also rose enough for 24-7 to continue blending biodiesel for a financial advantage. In another leveraged project, 24-7 utilized the sales lines they developed and the Kansas Soybean Commission's biodiesel rebate (administered by MEC) to get fleets to at least try biodiesel for 2000 gallons.

Figure I.1.1 The 24-7 Travel Store in McPherson, Kansas installed DCFC (Photo Credit: Tami Alexander)

Blue Springs School District (BSSD) originally planned to add time-fill CNG stations to its bus lot; however, when the Superintendent and Assistant Superintendent for Operations of BSSD both retired, new leadership was more focused on cost cutting, including for pupil transportation. Changing priorities for the district and an indefinite hold on new bus purchases meant that the district had to withdraw from the program. This withdrawal was formalized in the first quarter of 2020. MEC reassigned the $180,000 of federal funding originally slated for BSSD's fueling expansion to other projects described herein.

Kansas University (KU) Biodiesel Program does not receive direct funding from the project but benefits from technical assistance and relationship facilitation. As COVID-19 shut down the KU campus, which is located within the City of Lawrence, Kansas, biodiesel production ground to a halt in March of 2020. MEC had brokered an agreement with the city to use biodiesel produced by the Chemical Engineering Department's biodiesel program to fuel Parks and Recreation Department equipment, and to gather data from that deployment. This basic plan for deployment and data collection with the city remains unchanged, though delayed. COVID forced KU to close all dining halls, the main source of feedstock. As a result, KU partnered with local restaurants for limited feedstocks, even as COVID impacts slowed local restaurants' business to a crawl during winter 2020-21. In addition, the KU campus shutdown meant that only a skeleton crew of faculty and advisors was on hand for biodiesel production even as restrictions began to ease during the spring of 2021. Limited production resumed during the fall and winter 2020-21 semesters, but a spring 2021 batch just failed to meet ASTM specs.

During early 2021, KU Chemical Engineering upgraded its blending station for KU fleets to meet fuel specs and reset its testing process. City staff confirm that expanding biodiesel use fits the city's new sustainability goals and has support of the city council. The Parks and Recreation Department is willing to start with at least one big diesel mower and a tractor or two. KU was on track to set up its B20 fueling system in early 2022, with fueling of Parks and Recreation Department equipment beginning in March as seasonal work started. However, repeated failures to meet fuel spec and continuing difficulties resulting from COVID meant this deployment was indefinitely delayed. In addition, MEC is exploring the possibility of an Optimus engine system upfit to allow one vehicle (city or university) to run on B100, though securing funding will take additional work. Our hope is that positive outcomes from the Parks and Recreation Department test will encourage this move by project partners, should funding come through.

KU Research – Hydrogen Study. In late 2021, MEC expanded KU's scope of work to include hydrogen infrastructure integration research and brought them on as grant subrecipient. The study is focused on the potential conversion of compressed natural gas (CNG) filling stations to hydrogen. To support this effort, a graduate student working at the University of Kansas in conjunction with MEC researched the literature and provided a 20-page report documenting the findings, including information on the use of natural gas as a bridge fuel to hydrogen and specific siting requirements for hydrogen safety. MEC submitted the completed study to DOE in 2022, and the university plans to submit the final paper to technical publications.
DS Bus Lines, which provides contract bus services to Olathe Public Schools and other area school districts, applied for funding through the project's summer 2020 Request for Proposals and was added as a subrecipient under this project in 2021. DS Bus bought 30 late model used CNG buses from Midwest Bus Sales for deployment in Olathe using the City of Olathe's existing natural gas fueling facility. These buses were then leased to the Olathe School District. DS Bus completed purchasing, inspection, and transferring of the buses in June 2021. DS Bus deployed the buses in mid-August 2021 at the beginning of the fall semester.

The City of Olathe, Kansas, was also added as a subrecipient under this project in 2021. Olathe installed six mobile solar-powered electric charging stations at three popular community destinations: a library, a community center, and a lakeside park. The stations are not connected to the grid and required no construction. The City of Olathe held a public ribbon-cutting ceremony with MEC and Olathe's mayor and city council in attendance. The stations are open and free for public use. See Figure I.1.2 for an image of an Olathe EV charging at the solar-powered EVSE station during the city's community workshop.

Figure I.1.2 The City of Olathe, Kansas new EV and EVSE. (Photo credit: Jeff Windsor)

The city also added six electric Chevy Bolts to its fleet. These vehicles were deployed mid-July 2021 after vehicles were upfitted for city service, but shortly after initial deployment Chevrolet recalled the Bolts due to fire hazards. The vehicles were out of service as the city waited for Chevrolet to replace the recalled battery pack but are now back in service.

The city has been conducting outreach about the project, including via social media, local news media, and presentations to community organizations. The city held a community workshop and invited local fleet managers to showcase the project's accomplishments, impacts, and lessons learned.

The Kansas City (KC) Public Library was added as a subrecipient in 2021. The project scope was for the KC Library to purchase one electric bookmobile. The KC Library planned to charge the vehicle using existing outlets and did not anticipate installation of any infrastructure. Contract execution and procurement was expected in early 2022 with deployment in summer 2022; however, in mid-2022, the KC Library determined that they could not provide the necessary cost-share for the project and terminated their plans to participate. These funds were reallocated to the final corridor installations planned by subrecipient 24/7.

Conclusions

Market conditions affecting fuel pricing and the global pandemic played havoc with the original project plan, contributing to major changes to, or cancellation of, half of the original projects. Efforts to revise the project's focus toward achievable and beneficial outcomes have taken a considerable amount of time. The project's travel corridor focus has necessarily shifted from CNG at all target locations to biodiesel and DCFC, almost to the exclusion of CNG, due to cost concerns and return on investment, as diesel prices have been low in comparison to CNG. Recent volatility in the price of diesel may encourage renewed interest in CNG station installation in the future. MEC saw much more successful outcomes since making this shift in response to the local market. MEC is also increasing electrification of municipal fleets and is assisting the cities of Olathe, Kansas, and Kansas City, Missouri, with electrifying their fleets beyond this project. This innovation is bringing local and regional attention to flexible electrification strategies. Being able to adapt to changing needs, we have seen more progress towards alternative fuels adoption. Even with the challenges of COVID-19, the project has gained some momentum that should carry into 2023 and the final months of the project.

Lessons Learned:

- Financial returns and technology performance are some of the top concerns of fleet managers when considering alternative fuel projects. While the City of Garden City overcame the technological difficulties with the vehicles, they did not see their expected financial savings and expressed little interest in future CNG investments. In contrast, the City of Kansas City saw a lower than anticipated vehicle and infrastructure cost for the electric sedans, with high technology performance. Kansas City's successful pilot under this project paved the way for a 2021 commitment towards full fleet electrification. Kansas City also reports success with their CNG trash trucks and CNG water services trucks, however, and the city will likely continue with CNG medium- and heavy-duty vehicles until the cost of electrifying those vehicles is more reasonable.

- COVID-19 certainly has made an impact that continues, likely with long-term negative effects. The pandemic caused supply chain and equipment delivery delays. The disrupted schedules and impacted budgets, which caused the project to take on a new shape. It might take a few years to fully understand the impacts and paths forward for economic recovery, including for AFV investments. Counterbalancing this cluster of negative pandemic impacts is the recent passage of the federal infrastructure bill and new funding starting to come online in 2022 and 2023.

- An additional notable impact is that climate change activists are having a much bigger impact on municipal planning and policy than previously, and there is a much greater interest in electrification, even when investment costs are higher.

Key Publications

Metropolitan Energy Center. Case Study: Propane School Bus Fleet. https://metroenergy.org/wp-content/uploads/2021/04/FINAL_AFV17_Grain-Valley-School-District-Case-Study.pdf. 2021

I.2 Integrating Microtransit with Public Transit for Coordinated Multi-Modal Movement of People (Ford Motor Company)

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Start Date: October 1, 2018 End Date: September 30, 2023
Project Funding: $2,500,000 DOE share: $2,000,000 Non-DOE share: $500,000

Project Introduction

The growing presence of on-demand transportation services provides a unique opportunity to influence the urban mobility status quo, shifting from personally owned and operated vehicles to the Mobility as a Service (MaaS) paradigm. To be successful, microtransit (i.e., on-demand shuttles) service providers will need to be able to offer services that are seamlessly integrated with public transit and do so with a high degree of efficiency to make the service operationally and financially viable. In this project, we focus on the potential benefits of mobility service providers and transit agencies cooperating to offer fully integrated and seamless multi-modal mobility services for commuters. In particular, the project team is interested in the potential for energy savings via the adoption of MaaS by reducing the number of personal vehicle trips and encouraging higher occupancy transportation modes. While there has been considerable recent interest in using on-demand services as a solution to first/last mile connectivity, this is a challenging problem that is far from solved. There is not a clear indication that such solutions can be i) operationally efficient, ii) financially viable for operators and/or transit agencies, and iii) a convenient and compelling option for users. This project aims to improve the state of the art in first/last mile connectivity to mass transit via a fully integrated microtransit system. First, the team will develop, optimize, and test models in a simulation environment. Second, the team will conduct two pilot projects, working together with transit operators, to field-test the models developed with the simulation.

Objectives

The objective of the project is to research, develop, and demonstrate that a first/last mile mobility service, integrated with transit agencies' real-time transit and user data, works seamlessly in a simulation environment and a real-world pilot. The major expected outcomes of this project are:

1. A simulation environment for planning and optimizing a first/last mile mobility service that is seamlessly integrated with public transit (i.e., has access to real-time transit data).

2. Calibration of the behavioral components of the system via user surveys and field tests.

3. Two field experiments in Seattle, Washington in collaboration with King County Metro (KCM) providing first/last mile connections to public transit, one using microtransit and the other micromobility, such as e-scooters and e-bikes, operations.

4. Assessment of the potential benefit from implementing such a first/last mile system for public transit.

Approach

Our project addresses one of the fundamental challenges for both transit agencies and customers with microtransit: the lack of connectivity between microtransit and mainline transit services. Transit agencies around the country are launching microtransit pilot programs with the intention of helping riders to better connect with their mainline bus and rail services [1-3]. However, agencies cannot be sure these new services are complementing existing transit systems and not competing with them. To address this issue, we are developing a routing and dispatch algorithm optimized for serving the first/last mile need of fixed route transit customers. To ensure a seamless transfer to transit, our algorithm will leverage real-rime transit system data (GTFS-Realtime data) for assignment and routing. Not only will such an algorithm help ensure better connectivity between microtransit and mainline transit services, but it will also improve user experience for riders. To develop such an algorithm that is robust and broadly applicable, we have organized into three major workstreams.

In our first workstream, we dedicated several tasks to algorithm development, broadly segmented into simulation and survey tasks. Through the simulation, we developed demand models specific to our pilot program locations in the Seattle area. These models were used to test the algorithm against a range of fleet operations alternatives to help our transit agency partner plan for the pilot, while also ensuring algorithm functionality. We also deployed a survey to understand user preferences and used the result to calibrate the simulation model.

For the second workstream, our original plan was to pilot the algorithm in the real world. However, due to an insurmountable technical issue with the original software supplier (for implementing the algorithm), we made a major modification in 2021 and brought in The Routing Company (TRC) as the software provider for the pilots. In the end, in collaboration with KCM, we demonstrated the capabilities of microtransit service designed in this project in the Kent Valley. We also piloted a micromobility program in the Seattle Metropolitan area that incentivized transit customers to use e-bikes and e-scooters for accessing public transit. In the final workstream of this project, we focused on analyzing the field data, assessing the impact of microtransit and micromobility as a connector service to fixed route transit, and developing conclusions and recommendations for future work.

Results

2023 was the final year of this project and our collective project teams completed all remaining tasks of the project defined by the Statement of Project Objectives (SOPO). Major accomplishments included:

- Finished the17-month microtransit pilot in the Kent Valley in March 2023.
- Fielded the microtransit pilot user survey in late 2022; results published (internally) in March 2023.
- Launched the micromobility pilot in Seattle in Fall 2022, completed in September 2023.
- Fielded the micromobility user study late 2022, results published (internally) in September 2023.
- Conducted microtransit analysis and sensitivity study using field data.
- Continued research on integrating user behavior for better passenger-vehicle matching.
- Completed the micromobility rebalancing research.

- The team published two technical papers from this project in 2023 [4][5] and another one was accepted for publication in 2024 [6].
- Two final data sets, one created form the microtransit pilot and the other from the micromobility pilot, have been de-identified and will be made available to researchers on DOE's Livewire Data Platform (https://livewire.energy.gov) later in the year.

Microtransit Pilot: Ride Pingo to Transit

Launched on September 14, 2021, the Kent City microtransit pilot continued into early March of 2023. Using the software provided by TRC branded as "Ride Pingo to Transit," the service connects travelers to buses and trains at Kent Station as well as to key buses at a second hub in the Kent Valley. Riders can request a ride to the Kent Station or the Kent Valley transit hub using a feature called "Transit Connect" available in the Ride Pingo app. With this feature, riders can tell the app which bus or train they're trying to connect with from a list of potential transfers, all of them meeting the threhold of not too early that the microtransit cannot effectively deliver the rider to the transfer.

Ridership started off slowly but grew steadily over time. TRC launched a marketing campaign in October 2022 that also helped boost the ridership. The pilot began with two 13-passenger vans but a third one was added later for peak hour service in response to increased demand. By the end of the pilot in March 2023, ridership had reached an average 476 passenger trips per week with an average passenger per vehicle hour close to three.

During its 17 months in service, the pilot received 27,855 requests, of which 21,329 were served, representing a service rate of 77%[7]. The program moved 22,910 passengers including 1,006 ADA customers. In total the pilot served 2,844 Transit Connect requests, representing about 23% of all eligible hub drop-offs. There were 539 unique passengers of the service indicating that many were repeat customers. Our fleet accumulated a combined total of 65,954 PMT (Passenger Miles Traveled) and 95,474 VMT (Vehicle Miles Traveled), representing an average PMT to VMT ratio of 0.69. The program had its highest PMT/VMT ratio of 0.85 in the week of December 12, 2022. The pilot also received a consistently high customer satisfaction rating of 4.9 (out of 5).

Microtransit Pilot User Survey

By surveying residents living in the area of the pilot, we aimed to assess the impact of the first/last mile microtransit service offered by the pilot and gain some understanding who used the service, why they used it, and what were some of the perceived beneifts. Between October and December 2022, we emailed an invitation to people who had downloaded the Ride Pingo app to participate in an online survey. In total, 169 respondents completed the online survey of which 29% had never used the service, providing information about both users and non-users. We also recruited 15 riders from the survey respondents for online interviews. The purpose was to better understand how the microtransit service was affecting riders' lives.

This work yielded several important findings. First, most respondents mainly used Ride Pingo to connect to a bus or train, matching the very intent of the Ride Pingo service. Second, relatively few used the Transit Connect feature owing to several user experience factors, indicating significant opportunity for improvement. For those who did use the feature, they, by and large, were quite satisfied with the feature. Finally, while many survey respondents felt that Ride Pingo helped alleviate a variety of travel barriers across trip purposes, it did not dramatically reshape their access to mobility opportunities.

The Cornell team compiled detailed results of this work into a report and shared with internal stakeholders including Ford, KCM, and TRC. The full report will be included in this project's final technical report to DOE for public interest.

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[7] Unserved demand includes declined requests due to the capacity or timing constraint and requests cancelled by users after booking.

Micromobility Pilot: Bike and Scoot to Transit

The main objective of the micromobility pilot was to improve public understanding of which mode, microtransit or micromobility, was more suitable for first/last mile access to public transit. In addition, we wanted to learn how to integrate different micromobility operators and provide a unified process to subsidize qualified rides. Ford selected Bytemark as the software vendor for service aggregation, incentive management and data collection for the pilot, which was named Bike and Scoot to Transit. Bytemark worked with KCM, Sound Transit (ST), and Seattle DOT (SDOT) to identify mobility hub locations for the pilot. The pilot subsidized trips ending at those locations (up to a $8.00 per trip). The transit agencies in the area also distributed free transit passes associated with this pilot (with limitations). The program was effectively designed to encourage transit customers to bike or scoot to connect to public transit.

The pilot was launched in November 2022 and ran through the end of September 2023. Ridership started off low and stayed depressed during the winter months, but steadily improved as the weather got warmer. There were four operators participating in the program: Bird, Lime, Link (Superpedestrian) and Veo. A variety of e-bikes and e-scooters were offered by those operators. Together the four operators subsized a total of 19,226 qualified rides with scooters accounting for roughly three quarters of the total trips. The total amount of subsides paid out was about $73,000, averaging $3.81 per qualified trip. This implied that many riders rode to the transit stations for free. Figure I.2.1 shows the monthly ridership and subsidies paid over the course of the pilot.

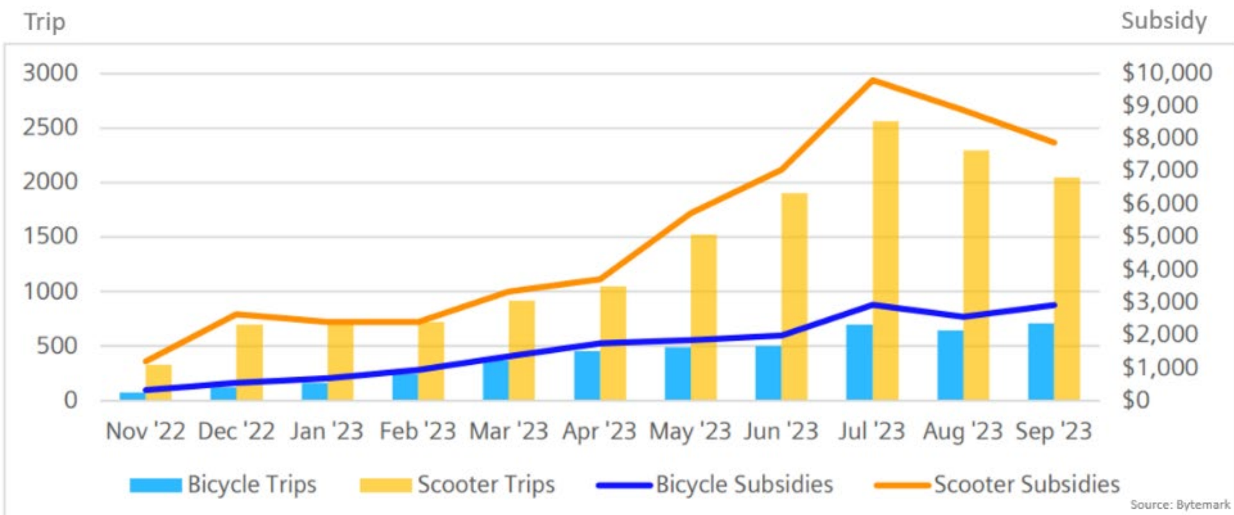

Figure I.2.1 Ridership and subsidies payout over the course of the Bike and Scoot to Transit pilot.

Micromobility Pilot User Survey

To understand how and why Seattle area residents used micromobility subsidies to access existing transit systems, we recruited survey participants at participating transit stations and hubs and a small number of additional participants using direct outreach via email. In total, 167 participants took our survey, 71 of whom had taken a subsidized bike or scooter trip as part of the Bike and Scoot to Transit pilot program. Survey respondents who participated in the pilot program differed from non-users who completed our survey. This gave us the opportunity to understand why people choose not to use the micromobility service for accessing transit. Finally, we augmented survey findings by analyzing data from over 11,000 subsidized trips.

This study yielded several important findings. First, our pilot was used more often by people of color and people from low-income families. Second, most people in this program rode scooters and bikes to connect to fixed-route transit systems, which was the intention of the pilot. Third, the service provided residents with an affordable, convenient way to access transit systems. However, like the microtransit service, respondents generally felt that this program did not dramatically change people's transportation options. Finally, while

there was some evidence that the micromobility service caused people to use transit more often, there was no evidence that either service had brought new customers into the transit systems.
The Cornell team complied detailed results of this work into a report and shared with internal stakeholders including Ford, KCM and Bytemark. The full report will be included in this project's final technical report to DOE for public interest.

Microtransit Pilot Performance Analysis and Sensitivity Study using Field Data

Using field data, we conducted an analysis to assess the effectiveness of the pilot operation. The main objective of this assessment was to ascertain whether the transit connect feature served as intended. We employed Key Performance Indicators (KPIs) such as service rate, vehicle travel miles, and customer waiting time as evaluation metrics. We then compared these real-world data with simulation results for those KPIs, and discussed the possible causes of any observed discrepancies. Finally, we performed sensitivity analysis for various counterfactual scenarios and discussed the potential impact of system constraints, including buffer time (i.e., the time by which a shuttle arrives at the station earlier than the targeted time to account for travel time variability).

Integrating User Behavior for Better Passenger-vehicle Matching

In collaboration with KCM, Cornell University continued to advance simulation modeling work. This included an algorithm that optimizes passenger-vehicle matching under user behavior considerations. The matching takes into account the future value of a vehicle's status, i.e., the expected revenue that the vehicle can earn during the remaining hours in a day. To capitalize the revenue potential, when accepting a request, the algorithm plans for the vehicle to take on additional passengers en route, resulting in additional travel time (detour time) by the requetser. However, the delay is guranteed to be under a maximum value set case by case. To do that, the model embeds a discrete choice model and trains a Markov Decision Process (MDP) to learn future values. A deep neural network is used to approximate the future value of vehicle status. The unique feature of this algorithm is its capability to determine a request-specific maximum detour time. We conducted experiments using New York City taxi data. We evaluated the algorithm across four scenarios, each with varying numbers of customers and vehicles, and presented the results of 50 repeated experiments using box plots. The algorithm generated the total system revenue during the morning peak hours (7:00 – 11:00 a.m.).

We compared our approach against four baselines: Baseline A and B employ a greedy online matching algorithm with a constant maximum detour (0 minutes for a strict maximum and 15 minutes for a loose maximum detour). Baselines A' and B' also use a constant maximum detour but incorporate trained values. Across all scenarios, A' generates higher revenue than A, and B' outperforms B, indicating that the training process enhances profitability. Furthermore, our matching algorithm, which suggests a request-specific maximum detour, yields the highest revenue in three out of the four scenarios, demonstrating the superiority of our novel approach. See Figure I.2.2. The Cornell team is trying to upgrade the training model for MDP to improve performance and make the model more robust to datasets with different distributions.

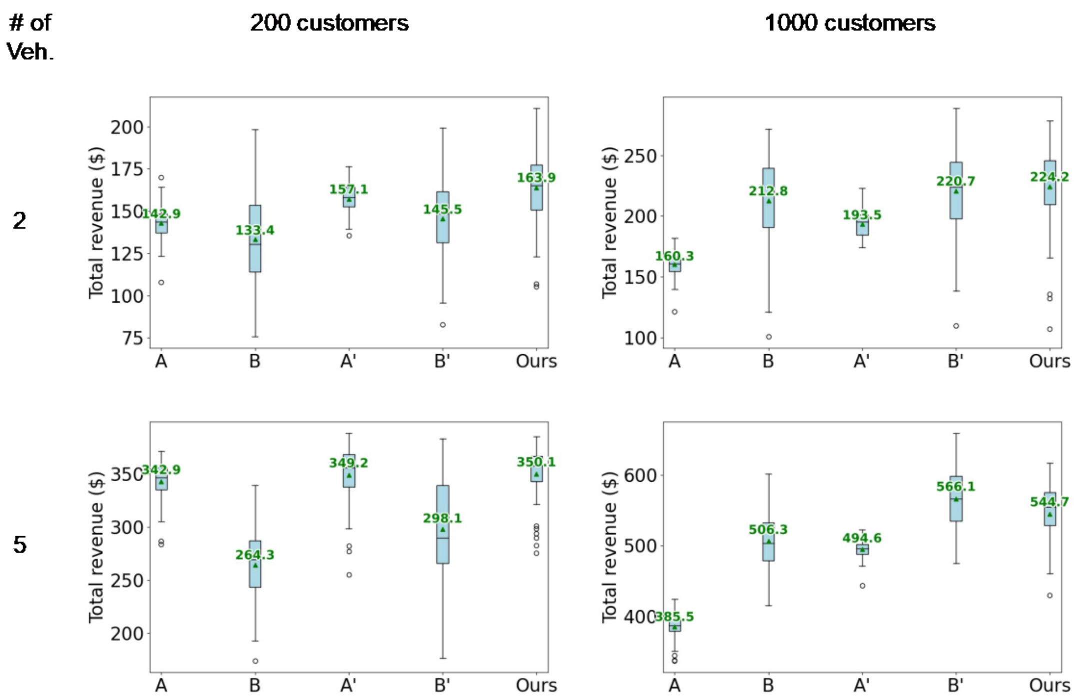

Figure I.2.2 Results from integrating user behavior considerations for better passenger-vehicle matching

Micromobility Rebalancing Research

To support the micromobility pilot, our Cornell team started new research in 2022 to leverage quantitative modeling to provide insights into how e-scooters could be used to improve urban mobility equity. The team explored some principles that inform the structure of contracts with e-scooter providers under permitting regulations. The Cornell team developed a novel stylized model that captured the key dynamics of e-scooter operators. The model considered two regions – the city center and a neighborhood. The city center has a higher rate of demand throughout the day but is already well served by transit. The neighborhood has demand patterns strongly influenced by commuting (to the city center) and is less well served by transit. The model provided valuable insights into the trade-off between the operator costs and service level required in the neighborhood region under several different rebalancing costs. The main takeaways were:

- The idea of 'commuting rebalancing' could be a cost-effective balancing method. In this method commuters (instead of the company) rebalance the system by taking e-scooters with them on transit (e.g., buses) while commuting in the morning or the evening. This ensures that e-scooters are present during commutes (thereby improving access to transit) while allowing increasing utilization during the day (once they are in the city center).
- Reducing the cost of rebalancing is key to getting the best trade-off between total trips completed by the system and improving access to public transit (in the neighborhood).
- A good potential metric for measuring service in regions is availability (% of time that an e-scooter with charge is close enough to a prospective user). This can be measured by app openings or estimated by using time-weighted demand and population density estimates.

The Cornell team did most of the modeling work in 2022 which was explained in last year's annual report. Since then, the Cornell team has improved/added more details to the data analysis, refined conclusions, and proposed future work. The team also finalized documentation which will be included in the project's final technical report.

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I.3 EVSE Innovation: Streetlight Charging in City Rights of Way (Metropolitan Energy Center)

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Start Date: October 1, 2018 End Date: December 31, 2023
Project Funding: $2,534,610 DOE share: $1,201,709 Non-DOE share: $1,332,901

Project Introduction

Streetlight charging for electric vehicles (EVs), whether on streets in central business districts or on residential streets, provides easy charging access for apartment residents and homeowners alike. Most EV drivers charge their vehicles at home, in their garages or driveways. For residents of multi-family properties, there are no such options. Most rental property owners are reluctant to provide EV charging, also known as electric vehicle supply equipment (EVSE), at their own expense. Opportunities for cost recovery are limited, and tenant turnover is far higher than rates of change in areas of single-family housing. Beyond that, residents of multi-family housing tend to have lower household incomes than homeowners. A used EV is an affordable option for a lower-income household, particularly when used as a commuter car; Edmunds [1] cites average 2018 EV costs ranging from 42% to 73% less than a comparable new model. Without easy access to charging, however, even a low-cost used EV is a non-starter for a prospective buyer, despite the demonstrated low total cost of ownership (TCO) of an EV. An affordable curbside charging network has the potential to expand EV adoption into neighborhoods that have, to date, seen minimal interest and uptake of the technology.

Objectives

The objective of this project is to expand the availability of EV charging at low cost in urban settings. We plan to use existing electrical infrastructure – streetlights – to provide on-street EV charging, as well as charging for multi-family residences, in Kansas City, Missouri (the City). By using grid-tied systems already in place, this approach can substantially cut installation costs and create a replicable approach for flexible, affordable charging systems that are feasible anywhere cities operate streetlights. This project will test charging and data technologies, track use of charging networks for on street and residential applications at 30 to 50 new EVSE locations and generate a process for siting EVSE while balancing concerns related to demand and equitable access.

Deployment equity matters, and one of the project's goals is to ensure availability of this EV charging network to residents, regardless of socio-economic or housing status. While the City's Permitting Office receives continual inquiries about EVSE installation from business owners in relatively prosperous areas, installing traditional on-street EVSE in low-income and rental neighborhoods remains for the most part cost-prohibitive. Lower income individuals and families could benefit the most from the long-term savings an inexpensive EV provides, yet they are least likely to have access to convenient, affordable charging networks. Geographic diversity is one part of unlocking the equity puzzle, and another is deployment in multi-family housing locations. A 2017 California draft study estimated installation costs of Level 2 charging for multi-family properties at an average price of $5,400, over triple the average cost for installation at a single-family residence. [2] Between 2006 and 2014, the percentage of Americans who rent rather than own rose from

36.1% to 41.1%. [3] With more people becoming renters, and residential EVSE more unattainable for renters, streetlight charging presents a more equitable alternative.

Approach

Metropolitan Energy Center (MEC) is working with several community partners on this project. Missouri University of Science and Technology (MST) built out a demand-driven model of potential siting locations. In 2021, the project research team from MST transferred to Penn State University (PSU) and continued researching demand and site selection considerations. The National Renewable Energy Laboratory (NREL) modeled potential locations based on equity concerns. MEC worked with all partners to gather additional siting criteria (i.e., costs, community interest, and impact on resiliency) and developed a site selection evaluation checklist. Community listening sessions revealed additional criteria. Simultaneously, LilyPad, Black and McDonald, the City of Kansas City, Missouri, and Evergy worked together to design the schematics for upgrading the streetlights and integrating and mounting the EVSE units. The City also led an effort to evaluate its policies related to EVSE and provided a list of best practices. Installations were finished and monitoring began in March of 2023.

Results

MEC successfully installed a total of 23 ChargePoint CT4013-GW1 Wall Mount Units across Kansas City in March of 2023. Locations were based on the demand-based siting model from MST and the equity-driven model from NREL, along with community feedback through outreach and scheduled listening sessions. MEC and Evergy are actively tracking usage data to be used in the final report and the predictive model for future installations in urban cities. See Figure I.3.1 for a map of the installed charging stations.

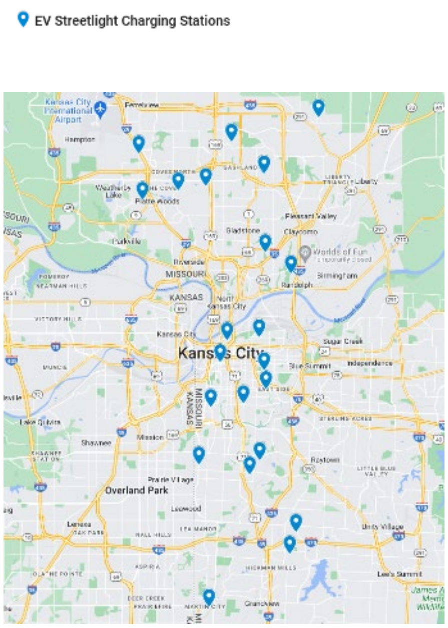

Figure I.3.1 Map of Installed Chargers

Siting

MST and NREL have completed the siting models. The data and approach used will be detailed in a final report. The MST model uses current usage statistics from existing charging stations and point of interest data to recommend specific candidate streetlight locations. The NREL model uses demographic data, including income, housing type, and EV adoption rates, to recommend broad areas of the city that are underserved by the existing charging network, and determine who may be likely to purchase an EV when the necessary infrastructure becomes accessible.

MEC and other project partners drafted site selection criteria that were used in the go/no go decisions. A site selection committee, comprised of project team members, was formed to determine which criteria would be included in the final decision-making process and how each factor would be weighted. Committee members determined that the first step in the process should be a review by the City's Streetlights and Parking Programs. The City compared the proposed sites with detailed streetlight asset data, as well as street parking and zoning data, to recommend sites for elimination. This process eliminated about two-thirds of the proposed sites. MEC eliminated a few additional sites in floodplains due to flood hazards and the likelihood of being flagged during the National Environmental Policy Act (NEPA) review process, causing delays. Site visits were delayed due to the COVID-19 pandemic but took place throughout 2021. Project subrecipients compiled checklists in preparation for the site visits.

While initially evaluating site feasibility, one surprise for the team was the discovery that a large percentage of City-owned streetlights were not built to code; they had been purchased from the utility and grandfathered in, so they did not have the expected electrical capacity, and would need more upgrades than previously thought. During the 2021 site visits, the project engineer selected streetlight poles for EVSE installation that would require the least costly upgrades. The project engineer eliminated more areas due to lack of suitable and cost-reasonable streetlight poles that could serve points of interest or multifamily residents.

MEC and project subrecipients conducted individual in-person site visits to document conditions and verify information and data collected from virtual site visits. This step captured invaluable information such as new points of interest, new infrastructure, additional community feedback, and other important information. A few additional site visits may be necessary based on community feedback on the proposed sites. All the data for each site has been captured in the site evaluation spreadsheet, including area demographics, land development, pole type, voltage, cost, community feedback, NEPA factors, and other data. The team also collected relevant data for the permitting process, parking review, and other city review and approval processes in the spreadsheet.

Progress in Q3 of CY22 was slow, due to the site host negotiations between Evergy and the City having to run through the City Council. The first presentation to Council on July 20 resulted in all parties having to re-evaluate sites selected to balance out the number of sites allocated to each council district. Though time consuming, the bigger delay came when trying to reschedule our second presentation to the council, which finally occurred on Sept 14. Council's approval on that date facilitated execution of the site host agreement by Sept 30. At the end of Q3 CY22, parties were finally all cleared to proceed with installation activities.
This latest delay resulted in one more amendment request to DOE for a final No Cost Time Extension to ensure deployment activities are conducted within BP2. Site visits are complete, and the selection committee has selected the top 30 sites. Sites were prioritized by choosing areas that overlap between the MST and NREL models, and sites with high cost-benefit ratios. MEC plans to analyze reasons for non-selection and incorporate this information into the final report.

During Q1 of CY23 all charging stations were completely installed, with a total of only 23 stations being installed rather than the 30 stations originally planned for. The seven stations not installed were primarily excluded due to complications that arose around easements and city bike lane plans rather than due to any community pushback. In fact, there was very little community pushback with only three local residents reaching out with concerns during the installation process. MEC and Evergy are now collecting usage data to determine which point of interest stations were a success and which ones were not. The usage data is tracked quarterly, so more detailed reports are contained within the second and third quarterly reports. The most popular stations so far are found in residential areas with multiple points of interest, and it does not seem like demographics have any effect on a station's success.

Engagement

NREL and MEC created a communications plan, which includes community listening sessions to gather data on end-user needs, as well as interests and concerns of area stakeholders who may not necessarily become end-users. The communications plan will continue to be fine-tuned with input from project partners, as well as area stakeholders. NREL executed a contract with EV Noire, a communications strategy consultant organization. MEC, NREL, and EV Noire drafted messaging for community outreach and engaged local organizations to assist with building out a stakeholder matrix of participants. Due to the ongoing COVID-19 pandemic, plans for community outreach were delayed. MEC, NREL, and EV Noire conducted two online community listening sessions in summer 2021, results of which will be incorporated into final site selection.

MEC began outreach to community organizations in early 2021 to inform them of the project and plans for site visits and finalized updates to the project webpage. Interested organizations can learn more about the project by visiting the project website, signing up for newsletters, participating in a listening session, or commenting on the project.

MEC delivered one targeted project presentation per request for an interested neighborhood association in early 2021. Feedback from residents was generally positive, but some attendees expressed concerns about parking. Residents voiced support for the proposed sites in their neighborhoods and agreed that sites should be located along the identified points of interest.

MEC, EVN, and NREL contracted with two local community organizations that represent the communities served by the project to support project outreach and engagement efforts. These two local partners assisted with prospecting and inviting other local organizations, disseminating project information, and providing feedback on content and outreach plans. Community partners also reviewed project information and documents for relevance to their community members. MEC and community partners conducted extensive outreach and invited community organizations, particularly those that represent traditionally underrepresented groups. Participants were incentivized to attend with gift cards.

Around a dozen individuals in total participated in the sessions, mostly from our targeted invitations. Diverse neighborhoods across the city were represented, and disadvantaged neighborhoods in the east side had a very strong showing in comparison to other areas of the city. No community members voiced opposition to the project, although there were calls for more equitable distribution across the city, especially in disadvantaged areas. There were also calls for more EV education, especially in disadvantaged areas with fewer EVs, where people may not be as knowledgeable or aware of EVs. See Figure I.3.2.

Throughout the rest of the year, MEC, EVNoire, and NREL worked on synthesizing the feedback from participants and incorporating it into site selection, city policy recommendations, and other relevant project activities, and presented it in a final report. Based on community feedback, MEC considered additional sites' feasibility in accordance with our approved Statement of Project Objectives.

Figure I.3.2 Local news broadcast of new streetlight chargers

Engineering

Black and McDonald provided pricing estimates and sample schematics for installation. Black and McDonald also designed an engineering plan and EVSE schematics. Lilypad EV determined the specifications for the ChargePoint CT4000 Level 2 commercial charging stations. The project team considered dual cord stations, but all 23 installed stations were single cord stations. The stations' mounting hardware did not have to be significantly altered.

City Policy

The project team met as part of the City's EV green group to finalize a draft policy framework and presented it to the Director's Subcommittee. The primary objective of the City Policy Feasibility document is to assess the current environment for EV charging in Kansas City, Missouri, explore ways to implement policy that supports those efforts, and proactively prepare for the growing market of EV users in the Kansas City metropolitan area. This report gave an overview based on current and national trends in the market of why EV implementation is vital for the future of the Kansas City community. The subcommittee gave MEC permission to share the draft with the rest of the project partners and MEC began to solicit input from them on the document. The City's EV green group considered this input as they finalized their specific recommendations.

This task was delayed due to reduced staff capacity at the City caused by turnover and the COVID-19 pandemic. In 2021, MEC worked with City staff to update and revise the policy draft and submitted a final draft to the Kansas City, Missouri Office of Environmental Quality.

From discussions with City staff, MEC identified several ordinances that could positively or negatively impact the project. The City has an ordinance to prohibit the parking of internal combustion engine (ICE) vehicles at EV parking spaces. Additionally, the City has an ordinance that requires the approval of adjacent property owners and tenants when parking in front of their property is restricted. Due to the restriction on ICE vehicles at EV parking spaces, this project required adjacent property owner and tenant notification. MEC had to obtain approval from Kansas City's Parks and Recreation department. MEC met with Parks and Recreation to present the project and requested review in late 2021. Both the Parks and Recreation Department and the Parking Program reviewed and approved the project in the summer of 2022, prior to permitting and installation.

Barriers

A new challenge with the equipment ownership plan has presented itself. The Missouri Public Service Commission (PSC), in the interest of preventing monopolies, has limited the number of charging stations Evergy is allowed to own. MEC contacted the PSC regarding this matter to resolve the issue through a waiver from the PSC. Evergy filed an appeal with the PSC in early 2021 and MEC submitted a letter of support for this filing. MEC and Evergy strategized alternate paths forward so that the project activities can continue in the meantime. MEC and Evergy considered 3 alternatives: 1) for MEC to own the chargers and later transfer ownership to Evergy or another party; 2) for MEC to own the chargers and lease them to Evergy; and 3) for Evergy to decommission some of their current chargers and replace them with the chargers under this project.

In 2021, MEC staff presented a draft plan to the MEC Board of Directors (BOD) for their consideration of option 1. The BOD expressed concerns with plans for MEC to own the chargers, due to the need for restructuring the organization and purchasing additional insurance. Insurance provision for EVSE is a major barrier for small and mid-size organizations; since actuarial tables have not been generated and this type of installation has not been incorporated into regular business practice, coverage is considered high risk and is cost prohibitive. Other project partners expressed similar concerns and will not consider ownership. Due to the ongoing PSC review of Evergy's charging station network, Evergy declined to consider option 3 any further at this time.

MEC continued to explore ownership options until we received a decision from the PSC. Installations were delayed until a viable ownership strategy could be established, in early 2022. Throughout 2021, MEC continued to provide relevant information to the PSC, Evergy, and the Missouri Office of Public Counsel as requested. In early 2022, the PSC issued its decision that Evergy may take on ownership of the chargers and Evergy and the City proceeded to finalize the site agreement with Evergy as the station owner.

Lessons Learned

- Using utility poles instead of streetlights may provide more cost-efficient installations as they tend to have more capacity and require fewer upgrades; however, adequate street lighting is a key safety factor for vehicle drivers according to community feedback.

- State and local policies and decision-makers may be unprepared for pilot projects of this nature, due to technological innovation, ownership considerations, right-of-way impacts, and community impacts. As such, project delays may occur as regulations and guidelines need to be updated by government agencies to allow the project to proceed. It is imperative that project leaders communicate with these entities early and often to navigate regulations, permits, approval processes, and other hurdles.

- While a data-driven approach to site selection is generally advised, real world limiting factors should have a greater impact on decision-making than theory or models. While a model may identify a proposed site as ideal, if it is not feasible or is opposed by the community or project partners, it cannot proceed. For example, many, if not most, of the DOE-identified Disadvantaged Communities (DACs) in Kansas City are primarily comprised of owner-occupied detached single-family houses. Sometimes these houses did not have access to off-street parking whereas multifamily units in other areas did. These concerns were specifically expressed to MEC and the City by EV-driving owner-occupants in the DACs without off-street parking access. Community input and site visits are imperative in conjunction with data to mitigate any bias or assumptions on the part of researchers.

- Some areas of the city are more suitable than others for streetlight charging, primarily due to availability of streetlights, curbside parking, multifamily housing, points of interest, traffic safety, and other factors. Since the existing conditions on which streetlight EVSE depend are distributed inequitably, proposed sites based on existing conditions and trends will also not be distributed equitably.

- Equity is a growing concern among policymakers, both at the local and federal levels. Projects like these may be paired with other initiatives in the future to meet the needs of diverse communities more comprehensively on a local level.
- Usage data demonstrates that the charging station locations with the highest demand are in residential areas and near multiple points of interest. Eight of the top 10 stations are in residential areas, with half of these being located around apartments and parks. Only 1 out of the top 10 stations is located near a single point of interest and 4 of the top 10 stations are in a commercial or mixed-use area.

Conclusions

This project has encountered many unexpected challenges, but it remains on target thanks to the flexibility and persistence of the project partners. Although the project team is seeing delays due to the COVID-19 pandemic and other factors, project staff are monitoring opportunities to lessen these delays and are preparing mitigating actions as necessary. Installations were completed by the end of March 2023. Now project staff is collecting and monitoring usage data to conduct an analysis of the stations' success.

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[3] https://www.citylab.com/equity/2016/02/the-rise-of-renting-in-the-us/462948/

I.4 NGV U.P.T.I.M.E. Analysis: Updated Performance Tracking Integrating Maintenance Expenses (Clean Fuels Ohio)

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Start Date: October 1, 2019 End Date: December 31, 2022
Project Funding: $950,000 DOE share: $450,000 Non-DOE share: $500,000

Project Introduction

The NGV U.P.T.I.M.E. Analysis project will quantify the difference in maintenance cost between diesel and compressed natural gas (CNG) freight and goods movement vehicles, identify and quantify technology and process improvements between older and newer generation natural gas vehicles (NGVs), and assess individual NGV fleets to identify opportunities to enhance operations using newly generated and legacy NGV and diesel fleet data. The NGV industry currently lacks comprehensive analysis and metrics regarding maintenance costs since users tend to be siloed by various use cases or competing in similar verticals. In addition, vehicle and engine manufacturers have been reticent to make this data widely available. This has led to a paucity of available information for current and prospective NGV users. There is little publicly available data that clearly compares the relative maintenance costs of NGVs and current advanced diesel trucks with modern exhaust aftertreatment systems (post-2010) to effectively capture recent NGV technology advancements, evaluate NGVs' potential to lower operating costs, and investigate claims of NGVs' lower total cost of ownership (ultimately improving cost-effectiveness and national energy security). NGV UPTIME's purpose is to bridge this information gap and facilitate an unbiased analysis drawing on a diverse dataset of national fleets to provide robust, real-world results for the broadest possible group of stakeholders. The project implemented a proven, multi-dataset analysis approach at both the system and component levels to determine the maintenance repair frequencies and cost differences between CNG engines (including previous and current state-of-the-art generations) and advanced clean-diesel engines (including post-2010 and post-2017 generations). The project results provided fleets, NGV industry stakeholders, and other end users with relevant, current, real-world information. The project results showcase the analysis findings (broken down by engine and/or fuel type) at the system, assembly, and component levels to better determine the NGV industry's current status and to identify specific research, development, and outreach needs.

Objectives

The objectives of the project are to quantify the difference in maintenance costs between diesel and CNG freight and goods movement vehicles; identify and quantify technology and process improvements between older and newer generation NGVs; and assess individual NGV fleets to identify opportunities to enhance operations using current and past NGV and diesel fleet data.

Approach

The project will include data from at least 1,041 total vehicles, accumulated across at least 383 vehicle months. Vehicles included in the data set will have accumulated a minimum of 200 miles and two calendar months of data, from medium- and heavy-duty natural gas (NG) fleets such as local, regional, and national freight and goods movement providers. The project will include raw data collection from current and historical vehicle use; data cleaning; analysis; compilation; summary; dissemination; visualization creation; reporting; national laboratories review; data set structuring and integration; and transfer to the U.S. Department of Energy (DOE).

This requires digital records of fleet operational, maintenance/repair, and fueling data and costs through Vehicle Maintenance Reporting Standards (VMRS) from fleet partners. The VMRS coding system is a way for the project to effectively collect, clean, and analyze common maintenance tracking descriptions and sub-systems across different fleets and to clearly see types of repairs done on the vehicles and the associated cost, labor, and parts for each specific repair. This data collection approach allowed the project to gather multiple similarly structured fleet data sets into a database and sort the maintenance data that are relevant to the analysis of the project.

Results

Clean Fuels Ohio has completed project tasks and deliverables which have led to the successful completion of a series of milestones in the third year of the project. Milestones from Year 3 include:

1. **Data Analysis and Summaries:** Complete individualized fleet data analyses, visualizations, and summaries for the combined dataset.

2. **Fleet-Specific Reports:** Complete and distribute fleet-specific reports from individualized fleet data analyses and data summaries.

3. **Final Report:** Complete and disseminate final report.

4. **Complete final dataset:** Final cleaned dataset is complete, consistent, and accurate, and is sufficient for final analysis.

Data Analysis and Summaries – Data Collection Process and Dataset Profile

The project team developed and finalized the project's data analysis and summaries that determined the maintenance cost differences between current generation NG trucks, previous generation NG trucks, and current generation diesel trucks for freight and goods movement applications. The data collection stage of this project proved to be particularly challenging. The project team spent the majority of the first two project years actively trying to recruit fleets. The network of Clean Cities project partners identified and pursued a total of 138 fleets. Project recruitment was somewhat successful in the first ~1.5 years in terms of securing the contract-required number of vehicles despite the COVID-19 pandemic. This included only three fleets, however, one of which is very large. Fleet 1 has an outsized influence on the demographics of the dataset due to its size, has a more aggressive sustainability initiative, and is phasing out its diesel vehicles. Despite having only three fleets willing to provide data at the end of the recruitment period, the data collection resulted in a dataset that included over 1,800 vehicles with at least one repair order (RO). The overall model-year range for all the vehicles in this dataset is relatively small, with almost all the vehicles falling within a 6-year range, from 2015 to 2021. This condensed range made it difficult to make comparisons between different generations of NG and diesel vehicles. Another important note is that the average NG truck is newer than the average diesel truck in this dataset, which can be attributed to Fleet 1's prioritization of purchasing NG-powered trucks starting in 2019. (See Figure I.4.1).

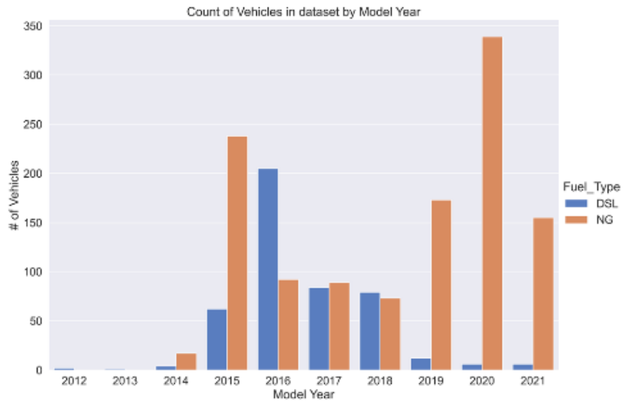

Figure I.4.1 Count of vehicles in dataset by model year

Total vehicle miles traveled for trucks in the dataset was just shy of 780 million miles, and the total number of usable ROs analyzed was approximately 244,500. The project team modified our analysis approach due to the limited number of participating fleets and the various data-quality issues. The distribution of ROs by model year shows that almost 80% of maintenance records in this dataset were generated by trucks that were manufactured between 2014 and 2017 (See Figure I.4.2). This condensed timeframe of available data made it difficult to make comparisons between different vehicle generations.

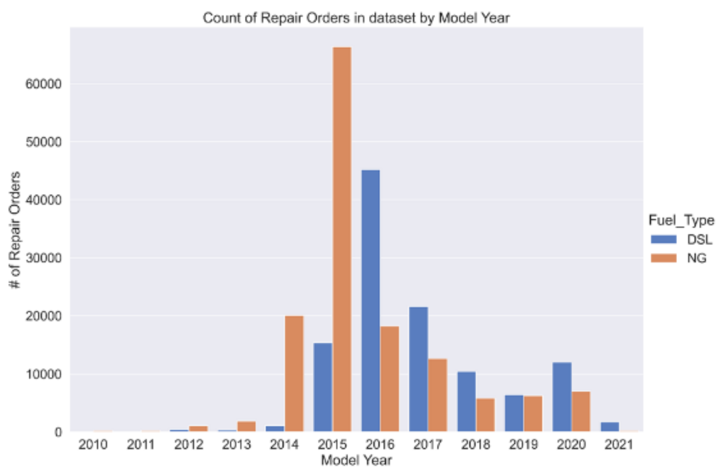

Figure I.4.2 Number of repair orders by vehicle model year and fuel type

Data Analysis and Summaries – Overall Analysis and Findings

In many instances, it was not possible or appropriate to make direct comparisons between the three fleets due to the differences in data completeness. Despite these data issues, the team was still able to make interesting observations from the project's dataset. Our initial expectation was that CNG trucks would require higher amounts of maintenance than diesel earlier in their lifespan. This theory was based on the assumption that NGV engines have shorter oil change intervals and require more routine maintenance for their ignition and fuel systems. Diesel trucks were expected to require more maintenance than NGVs toward the end of their lifespans due to the complicated exhaust aftertreatment systems required for diesel engines, which we thought would become more expensive to maintain (and replace) as the trucks age. NG engines, by comparison, have much simpler three-way catalytic converters for exhaust aftertreatment and are typically maintenance-free for the life of the truck. The results revealed that NG trucks required more maintenance than their diesel counterparts, but the maintenance costs never reached the expected parity between the two fuel types. The NG trucks in this dataset generated more repair orders and required more maintenance expenditures than their diesel counterparts at almost every odometer range. This trend was observed in the maintenance data from all three participating fleets. Further investigation revealed that the powerplant, cooling, ignition, and exhaust systems accounted for most of these observed differences.

Regarding VMRS component-level repair frequency, only Fleet 1 was able to provide data so only their data is used for the specific component-level analysis. This began by identifying differences at the broadest VMRS system level. See Figure I.4.3 for the average count of repair orders for each of the fuel type significant VMRS system codes. As expected, the average count of ROs for the ignition and exhaust systems were significantly different between the two fuel types since diesel engines have more complex exhaust systems, and NG engines have more complex ignition systems. The differences seen in the number of ROs for the power plant, fuel, and cooling systems were unanticipated.

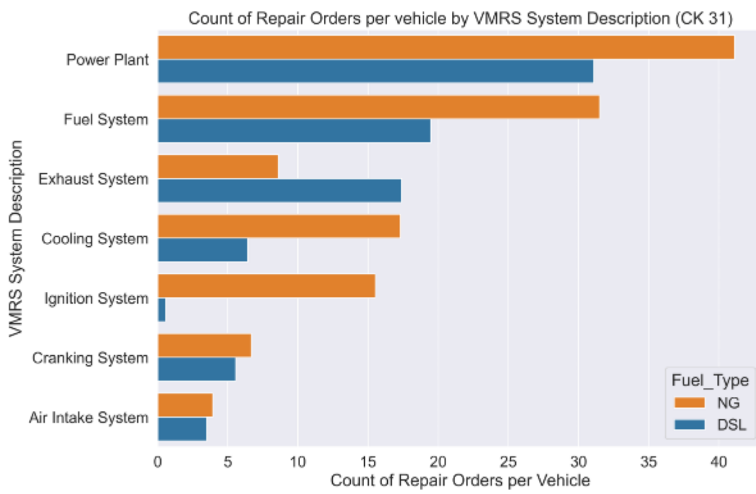

Figure I.4.3 Average count of repair orders by fuel type and VMRS system

Energetics subject matter staff met with Project Advisory Committee member Cummins at the conclusion of the data analysis phase to share the project approach, discuss results, and learn additional insights from Cummins' experience. As detailed earlier, the specific component-level analysis for all these systems revealed some interesting differences between diesel and NG. The powerplant system required the most maintenance for both fuel types, but the NG trucks had significantly more ROs for the cylinder head component than the diesel trucks. Cummins mentioned that the NG engines require more frequent valve adjustments than diesel engines. This could explain some of the differences in cylinder head-related maintenance. The cooling system also had unexpectedly large differences in maintenance frequency and cost between the two fuel types. Radiator-related failures were the leading cause. The NG trucks experienced significantly more cooling system failures than the diesel trucks. Cummins noted that the company provides diesel and NG truck manufacturers with cooling system specifications for its engines but does not provide the cooling system components or review/approve the integrations. We did not collect sufficient data to determine the cause of the higher cooling system failure rates with the NG engines, however.

The NG trucks accumulated three times as many turbocharger related ROs as the diesel trucks. Cummins mentioned that the turbochargers may be experiencing premature wear due to the higher NG combustion exhaust gas temperatures, causing turbocharger reliability issues. The costs associated with the additional turbocharger maintenance required for NG trucks offset most of the advantages gained from their simpler/less costly exhaust aftertreatment systems. The diesel trucks generated three times as many exhaust system-related

ROs, but the average exhaust system-related costs were very similar between the two engine types. Figure I.4.4 shows the flow of dollars for the exhaust system maintenance expenditures. The emission controls assembly and the catalytic converter component required the most maintenance within this system for both fuel types. The diesel truck costs were 2.5 times the NG truck costs for the emission controls assembly, but the NG trucks required almost 5 times as much spending for the turbocharger assembly maintenance.

We saw that the turbocharger component itself was the cause of most of the repair orders within this assembly. Cummins staff noted that the NGV UPTIME project findings are similar to the findings from their internal analyses, which have been/are being used to guide the development of Cummins' recent and future spark-ignited engine families, with the goal of reducing maintenance costs and improving reliability to be on par with diesel.

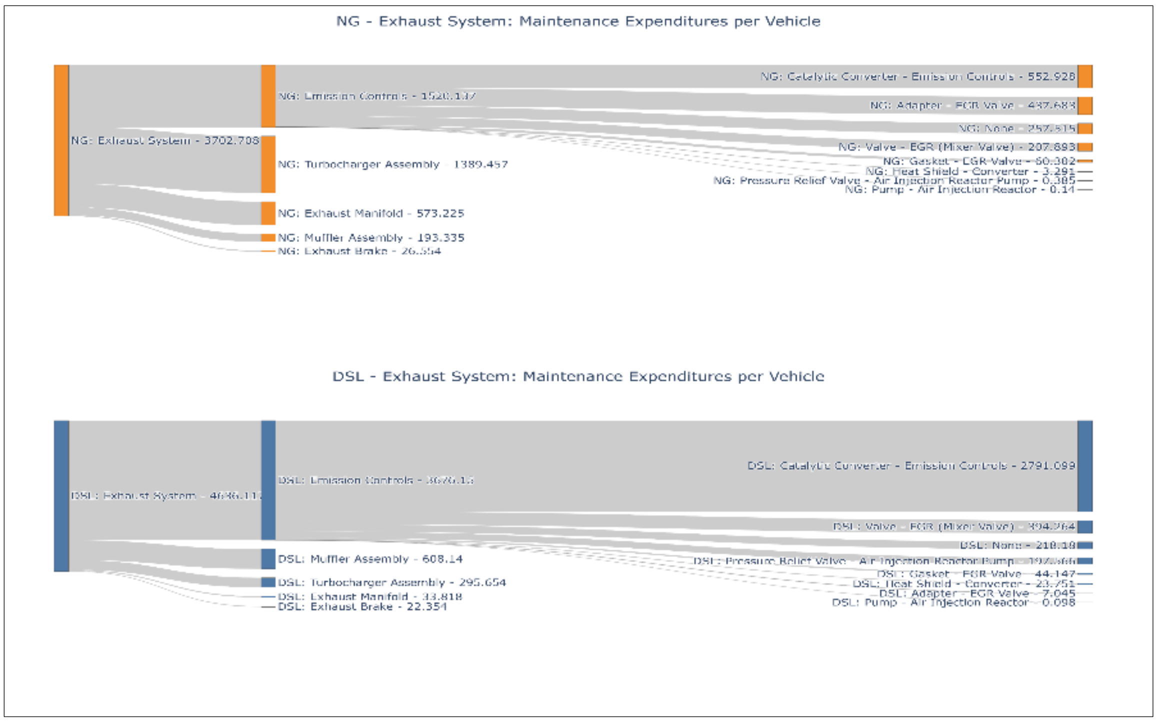

Figure I.4.4 Sankey plots of average maintenance costs per active vehicle for exhaust system components

This study's results quantified the key differences in maintenance frequency and costs between NG and diesel trucks. Data limitations did not allow for performing the planned comprehensive analysis, however. With the established data and analysis framework, gaining access to a larger and broader dataset with more variety and data granularity (i.e., at the component level) would allow for better analysis of the reliability improvements across NG engine generations and make it more feasible to pinpoint areas that would benefit from additional development. This information would allow NG engine Original Equipment Manufacturers to make the improvements necessary to better align the maintenance requirements for diesel and NG engines. Eliminating this maintenance disparity between the two fuel types would remove one of the biggest hurdles and consumer adoption barriers for NGV adoption.

Fleet-Specific Reports

Energetics developed and finalized three (3) fleet-specific reports (See Figure I.4.5) that highlight the most important and specific insightful interpretations for each of the three individual fleet data partners' data sets. Each fleet-specific report includes a summary of the respective data partner's fleet vehicle profile/makeup, the data cleaning process, analysis assumptions, and visuals for dataset profiles (vehicle data and maintenance data), overall repair frequency, component level repair frequency, overall cost analysis, component level cost analysis, and overall impressions and conclusions.

Figure I.4.5 Example of individual fleet data partner maintenance data analysis results summary

Final Report

The project team developed the final report of the NGV UPTIME Analysis project which summarizes in detail the efforts of this NG and diesel counterpart vehicle maintenance study. The final report (See Figure I.4.6) captures and evaluates one of the biggest barriers to NG engine adoption: maintenance. Specifically, the project team sought to evaluate the differences in maintenance frequency and costs between various generations of heavy-duty NG engines and current diesel engines in the freight and goods movement sector. A link to the final report can be found in the Key Publications section below.

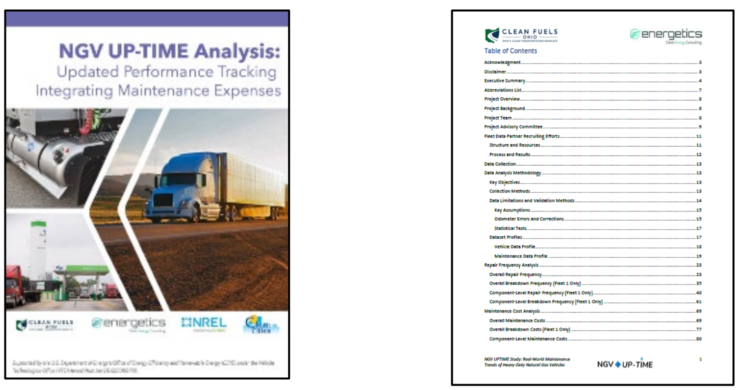

Figure I.4.6 NGV UPTIME Analysis final report cover page and Table of Contents page

Complete final dataset

Clean Fuels Ohio and Energetics finalized assembly of the anonymized dataset of NG and diesel vehicles maintenance costs and data. Clean Fuels Ohio also provided high level meta data information, the project logo, project description, and the dataset description to the NREL Livewire team. The NGV UPTIME project and dataset page became "live" on Livewire in June 2022. The final dataset is available at the weblink: https://livewire.energy.gov/project/ngv-uptime.

Conclusions

Clean Fuels Ohio wrapped up the NGV UPTIME Analysis project in December 2022 and accomplished its four milestones for the third year of the project. While the project team experienced the key challenge of differences in data completeness between the three fleet data partners, the project still made insightful observations from the project's dataset of over 1,800 vehicles. The project results were shared with trucking/freight fleets, NGV industry stakeholders, and other end users with relevant current real-world information. The project team received feedback from key NG industry stakeholders that the findings of the study are similar to internal analyses and will be used to guide the development of future NG spark-ignited engine types, with the goal of reducing maintenance costs and improving reliability to be on par with diesel counterparts. The project results quantified the key differences in maintenance frequency and costs between NG and diesel trucks, but data limitations did not allow for performing the most robust comprehensive analysis. With the established data and analysis framework, however, gaining access to a larger and broader dataset with more variety and data granularity (i.e., component level) would allow for better analysis results of the reliability improvements across NG engine generations and make it more feasible to pinpoint areas that would benefit from additional development. This information would in turn allow NG engine OEMs to make the improvements necessary to better align the maintenance requirements for diesel and NG. Eliminating this maintenance disparity between the two fuel types would remove one of the biggest hurdles and consumer adoption barrier for NGVs. The project results showcased the analysis findings (broken down by engine and/or fuel type) at the system, assembly, and component levels to better determine the NGV industry's status and to identify specific research, development, and outreach needs.

Key Publications

NGV UPTIME Analysis Final Report
NGV UPTIME Analysis Dataset (Livewire) Note: You must sign into a Livewire account to view the dataset.

I.5 Smart CNG Station Deployment (GTI Energy)

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Start Date: October 1, 2019 End Date: December 31, 2023
Project Funding: $3,999,781 DOE share: $1,999,789 Non-DOE share: $1,999,992

Project Introduction

State-of-the-art compressed natural gas (CNG) stations fill vehicles directly from a CNG compressor or using a combination of the compressor and high-pressure storage tanks. The gas is delivered to the vehicle using a dispenser that processes payment, controls the filling sequence, and determines when the vehicle is full. Unfortunately, current dispensers consistently underfill vehicles due to issues arising from the gaseous nature of the fuel. During the filling process the pressure of the fuel in the tank increases from a low to a high level. As this happens the temperature of the gas rises due to a phenomenon known as the heat of compression. Immediately following fueling, the temperature in the vehicle cylinders is often greater than 120°F. Because gas expands as its temperature rises, its pressure increases due to this warming effect and the pressure gauge indicates a 'full' cylinder even though the vessel is under-filled compared to its maximum capacity. Natural gas vehicle (NGV) fuel systems are typically oversized in response to this systematic underfilling. Increased utilization of the vehicle's fuel storage capacity will allow a reduction in the size of NGV tanks, which can lower fuel system cost by as much as 20-25%. This project is addressing the development, demonstration, and deployment of a complete smart CNG filling solution to overcome the barriers preventing full fills.

GTI Energy (formerly Gas Technology Institute [GTI]) possesses decades of CNG filling experience, including numerous projects related to vehicle and station component design and testing, as well as operation of a public CNG fueling station. Relevant projects include the development and licensing of GTI's AccuFill CNG dispenser algorithm for non-communications-based fills, the recent development of a smart dispenser algorithm for the California Energy Commission using wireless communications, and many other gas industry funded projects. These projects have resulted in a unique understanding of the barriers that prevent full fills.

Objectives

The overall goal of the smart CNG station deployment project is to develop an advanced vehicle and station solution for maximizing a CNG fill with or without pre-cooling of the natural gas. CNG stations without pre-cooling will be able to immediately see safer, fuller fills of their vehicles using the communications hardware and an advanced control algorithm. Stations with existing or retrofitted pre-cooling systems will be able to guarantee consistent full fills year-round regardless of the ambient conditions. The project will demonstrate a definitive improvement in fill quality, safety, and consistency using commercial vehicles, enabling an increase of up to 25% in the usable CNG storage capacity.

Approach

The project, as originally planned, included the development, demonstration, and field deployment of sensors, software, and communication systems on multiple smart vehicles and dispensers that were to be programmed with an advanced control algorithm to maximize full fills. The combination of these technologies is designed to solve the issues of dispensing uncertainty and elevated pressures from heat of compression that result in NGVs being under-filled. Several of the demonstration locations were going to include CNG pre-cooling to help overcome the heat of compression during a fill. Because of changes to GTI Energy's proposed partners, which included new management and upsets in the CNG market, this project had to be restructured with a new commercialization partner and a new development and demonstration plan.

GTI is now working closely with ANGI Energy Systems LLC (ANGI), a U.S. based manufacturer of quality engineered gas compression equipment and a leading supplier of CNG refueling equipment and systems. ANGI has a longstanding reputation as a leader and innovator in both the Compression and NGV Refueling Station industries and has over 30 years of experience providing worldwide clients with high quality products and services. To ensure the project results in a commercially viable solution for the CNG industry, GTI's team is also partnered with Ozinga Brothers, Inc. (Ozinga) to demonstrate fuller fills onboard their fleet of concrete mixers and support vehicles. Ozinga is a major concrete provider in the Chicago area, with many light- and heavy-duty CNG vehicles. These vehicles consume large amounts of fuel in a variety of weather conditions, making them an excellent test bed for collecting baseline filling data and comparing that to the improved fills received from a smart filling solution.

The revised project plan calls for installation of a commercial ANGI CNG dispenser at GTI's facility in Des Plaines, IL instead of multiple dispensers being installed in various locations and weather conditions. The first step in demonstrating and achieving full fills is still to establish a diverse dataset of baseline dispenser performance. This is being accomplished by leveraging Ozinga fleet vehicles instrumented with data acquisition units collecting mileage, fuel consumption, CNG pressure and temperature, and other relevant data. The team will collect baseline and smart-filling data for at least a year on multiple Ozinga trucks. This will ensure the performance of the baseline and smart station systems are fully characterized and quantified over a wide range of operating conditions (ambient temperatures, truck configurations and duty cycles, etc.). The vehicles used in the demonstration will include several models of concrete mixers that operate in and around the Chicago area. By ensuring a mix of fleet vehicles and weather conditions the team will evaluate the impact these variables can have on a fill.

Concurrent to the baseline data collection, the team will build on GTI's extensive previous work to develop a prototype smart refueling system for CNG stations and vehicles. The team will design a smart vehicle module to fit within a vehicle and interface with temperature and pressure sensors on the fuel system. In addition to temperature and pressure, the smart vehicle module will be programmed to detect the CNG fuel system volume, tank quantity and type, tank age, last date of inspection, and other relevant information, which will be very useful to fleets and maintenance technicians. The vehicle module will have the option of connecting to the onboard computer or Controller Area Network (CAN) bus to access information such as total fuel consumption and usage rate. It will be integrated with wireless communications to transmit data to the fleet operator at its base or to the dispenser during filling.

The smart dispenser module must be designed to be fully compatible with any smart vehicle module it detects, while also being able to operate with new and existing commercial dispensers. Therefore, one of the first requirements is to establish communication between the dispenser and the vehicle(s) and to enable the dispenser to identify the specific vehicle it is filling. The team will install a device outside the dispenser cabinet that will be designed with multiple input and output interfaces to enable communication between the smart module and the existing dispenser logic. Future dispensers could have smart software and communications hardware directly integrated into the dispenser; however, GTI sees the need for a near term, universal solution to ensure industry-wide adoption. Therefore, the proposed design will interface with the dispenser software and override the existing filling logic when a smart vehicle is detected. The vehicle's state of fill will be actively calculated using the information transmitted from the vehicle. In the case where communications are lost, the smart dispenser module will indicate that the dispenser should revert to its existing non-communications-based filling algorithm.

In the revised development and demonstration plan, the team focused on developing vehicle and dispenser data acquisition systems (DAS) and smart module prototypes loaded with GTI's advanced dispenser control algorithm and integrated into a simulated dispenser. Upon verification that the algorithm and controls were working in a laboratory environment, the team integrated the prototype smart module into an operational dispenser and multiple vehicle fuel systems. The dispenser manufacturer is supporting extensive testing to ensure the seamless and reliable integration of the smart components into their dispenser, while also ensuring the advanced full fill algorithm continues to perform as designed, safely and accurately filling vehicles.

Following the successful integration of the smart modules, the field deployment will include testing of the systems onboard the vehicles, with all filling operations taking place at GTI. The team will verify each of the systems is operating correctly, resulting in a seamless connection between the vehicle and dispenser, and filling according to the smart filling algorithm. These vehicles and the smart dispenser will be operated for at least a year to capture the smart CNG station results across a wide range of filling conditions and to compare performance to the baseline. The team expects the addition of the smart components will significantly improve full fills on their own. However, pre-cooling will also be tested to achieve full fills on hot days. The anticipated improvements will enable the complete utilization of the CNG storage system. The project was extended due to delays caused by the COVID pandemic and the change of partners so that it will occur over 60 months.

Results

GTI has developed a prototype smart station communication system to automatically monitor CNG fills and ensure every vehicle receives the maximum fill possible on a given day without overfilling. The system starts with 10 HEM DAS that GTI assembled and installed on six Ozinga cement trucks. The remaining four were supposed to be delivered to Clean Energy but have instead been used for lab testing and debugging. All 10 HEM DAS are designed to be powered by the vehicle so that they can monitor pressure and temperature sensors connected to the vehicle's CNG cylinders. The measured data is then transmitted onto the vehicle's CAN bus so that various systems onboard the vehicle can use the information.

The first component in the chain of communication is the vehicle streamer that monitors data on the vehicle's CAN bus. The streamer, developed by GTI, uses an ESP32 microcontroller that monitors the vehicle CAN data in real time, filters the signals looking for the pressure and temperature data added by the HEM DAS, adds some vehicle specific information such as the number of tanks, and then broadcasts the data package off the vehicle to the CNG station's Wi-Fi network. An example of the ESP32 is pictured in Figure I.5.1.

Figure I.5.1 An example of the ESP32 microprocess developed for installation inside a dispenser

At the other end of the chain of communication is an ANGI dispenser that was installed at GTI's facilities in Des Plaines, IL. The dispenser was commissioned in July 2023. The ANGI dispenser, like most commercial dispensers, can be connected to a Modbus network and monitored remotely. Photographs of the dispenser installed in the laboratory at GTI are shown in Figure I.5.2

Figure I.5.2 The fully installed ANGI dispenser was moved into the test chamber along with two target cylinders.

GTI's smart controller is used to monitor both ends of the communication chain. It is hardwired into the station's Wi-Fi network, enabling it to monitor all connected vehicles broadcasting data through their streamer and at the same time it acts as the Modbus master that can monitor the real time status of multiple CNG dispensers. This system is shown in the photographs in Figure I.5.3. In the left image, inside the pelican case, are the HEM DAS and streamer that are connected to the tanks in the background. The streamer is then connected to the Wi-Fi router in the center image that is hardwired to the micro-controller in the righthand image. The micro-controller is then hardwired to the ANGI dispenser.

Figure I.5.3 (LEFT) One of the HEM DAS with a built-in streamer. (CENTER) The router connected to the HEM DAS. (RIGHT) The micro-controller that connects the dispenser to the vehicle.

GTI's Smart Controller is designed to monitor data from multiple dispensers and vehicles simultaneously. A schematic of this system is shown in Figure I.5.4. Approved vehicles that enter the station will be able to connect to the Wi-Fi router and will then transmit their data to the smart controller. This allows the GTI controller to see every smart vehicle and dispenser in real time. When a fill is initialized, the controller starts matching the dispenser to the vehicle. The matching logic continuously monitors the dispenser and vehicle throughout the fill to ensure they are connected and then only intervenes in the fill when the vehicle is almost full. This is done by overriding the target pressure that was set in the dispenser and updating that target in real time to add more gas to the vehicle until it is full or has reached the pressure limit of the CNG tanks.

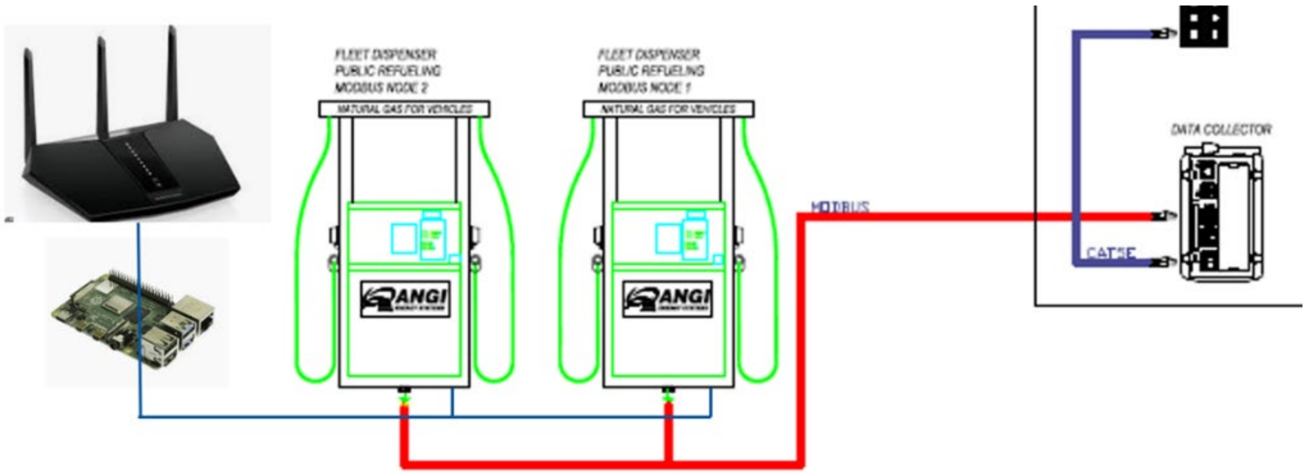

Figure I.5.4 GTI Energy developed a single-board computer that can control multiple dispensers, time fill, and other station safety features simultaneously. The computer is connected between the station's Wi-Fi router and the dispenser's secondary modbus network represented by the blue line.

Preliminary Data Analysis

GTI has complete preliminary testing using the system described above. The smart controller is receiving data from both the vehicles and the dispenser in real time. GTI is debugging some of the programming and control logic, and then will test the functionality of the smart components across a wide range of filling conditions before the end of 2023.

Conclusions

GTI has proven in previous research that a more sophisticated algorithm, employing strategic temperature and pressure data from onboard sensors, can be used to control a CNG dispenser and provide more complete fills of NGV fuel systems. GTI is working with industry experts to develop vehicle and dispenser hardware that will securely connect when fueling to provide a safer, improved full fill. GTI has demonstrated this equipment on the bench and during preliminary testing. GTI conducted several fills to demonstrate that the smart vehicle could be identified and that a secure connection could be established. Real time data was sent from the vehicle to the dispenser, which will be used for development moving forward.

I.6 Next Generation NGV Driver Information System (GTI Energy)

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Project Funding: $1,600,000 DOE share: $600,000 Non-DOE share: $1,000,000

Project Introduction

Measuring the amount of fuel contained in the tank of a Natural Gas Vehicle (NGV) is not as straightforward as it is for a liquid-fueled vehicle. The fuel in an NGV is a compressed gas, and its pressure changes with temperature. If the gas temperature goes up – for the same amount of gas in a tank – then the pressure goes up. If the temperature goes down, then the pressure goes down. To complicate matters further, the temperature of the gas does not simply vary in response to the ambient temperature, but it also changes as a function of filling or emptying the tank through what is called the heat of compression. Whereas knowing a liquid level in a gasoline or diesel vehicle will provide an accurate measure of the volume of fuel (and energy) on-board the vehicle at any time, there is no corresponding single-value indicator of NGV fuel volume or energy content.

The current state-of-the-art, which is used on most NGVs, is a simple pressure gauge as a rough guide for remaining fuel. This presents a high degree of error because pressure varies widely depending on temperature. Immediately following fueling, the temperature in the vehicle's cylinders is often greater than 150°F. The pressure gauge indicates a 'full' cylinder even though the vessel is under-filled compared to the target fill capacity. As the driver pulls out of the fueling station and begins consuming gas, the pressure drops at a very fast rate due to isentropic cooling of the gas. This pressure drop appears to the driver to be a very rapid decrease in fuel level, reducing trust in the fuel level indication and leading to concern about the distance the vehicle can travel before refueling again, which is known as "range anxiety."

The cost of range anxiety is difficult to quantify due to dependence on driver experience. However, initial discussions with vehicle owners indicated they return for fueling when their vehicle tanks are still 20-40% full. Decreasing the remaining fuel content to below 10% before refueling would result in significant time and cost savings. The simplest way to quantify these savings is with fuel system costs. NGV fuel systems are typically oversized in response to full-fill difficulties and range anxiety. By increasing confidence in the fuel status of the vehicle, the fuel storage capacity can be reduced, which can lower fuel system cost by as much as 20%.

Objectives

The objective of this project is to develop and demonstrate a more accurate NGV Driver Information System that includes a prediction of the remaining distance-to-empty (DTE) within 5% or 25 miles (whichever is greater) at any time during vehicle operation. The predictive model will increase the driver's confidence in the remaining vehicle range and allow a reduction of on-board fuel capacity or frequency of fueling stops.

Approach

The calculation of the remaining DTE depends on the usable fuel quantity in the vehicle and on the average fuel economy along the upcoming route. These two values must be properly measured and predicted, respectively, to accomplish the goal of this project. GTI Energy (GTI) has addressed the estimation of the usable fuel remaining on the vehicle with the development of a new model relating Compressed Natural Gas

(CNG) tank pressure to ambient temperature, on-board gas temperature, and estimated fuel system volume and gas characteristics. To predict the expected average fuel economy for a given route, GTI's partner, Argonne National Laboratory (ANL), developed a second, predictive model of the required fuel based on historic powertrain efficiency, and average speed, among other parameters. These models make use of the fundamental thermodynamics of the problem and employ machine learning tools that will continually improve the calculated results.

Once the two models were developed, they were implemented in a mobile app to display a real-time DTE prediction to the driver. This app will be used for both driver guidance and fleet management. In recent meetings our field test partner expressed interest in using the information on truck fuel efficiency that this app can provide to measure and reward driver performance. This could be an added benefit of the NGV Driver Information System.

Results

Data Collection

In Budget Period 1 GTI built and tested two different DAS and then installed the system that used parts from HEM Data on 12 trucks, owned and operated by Ozinga Brothers, a major concrete provider in the Chicago area. The HEM DAS collects CAN (Controller Area Network) bus data from the vehicle and added sensors on the fuel tanks and transmits it over Wi-Fi and cellular networks. GTI installed thermocouples and pressure transducers on the CNG tanks on nine of the trucks. GTI used two methods of retrieving data: one through the HEM datalogger with a cellular connection and the second through a Google Pixel phone which carries the App developed by ANL, with both sending data to a cloud server.

GTI collected and analyzed the data to measure and evaluate system performance. Several critical issues had to be resolved, including finding the right data source and transmitting large volumes of data reliably. Some trucks required multiple connection attempts before the correct bus contacts were identified and a data link was established. The data revealed that the Ozinga trucks spend a significant fraction of their operating time idling while the concrete mixer is loading or dispensing product. This increases uncertainty in DTE predictions since the truck is not moving and yet the fuel consumption can be great because of the load represented by the turning drum. ANL and GTI dealt with this uncertainty by predicting a range of DTE values.

Data Analysis and Distance-to-Empty Predictions

The application developed by ANL estimates the mass of natural gas in the tanks using various parameters. Equations 1through 3 below provide an explanation of how the VM_{ng}/R_{ng} parameter is related to the mass estimation process. Equation 1 shows the relationship between this parameter, the measured tank conditions (c_0, c_k), and the consumed fuel mass flow (m_f) obtained from the CAN bus. Equation 2 relates the tank pressure (p_k), temperature (T_k) and real gas coefficient (Z_k) to VM_{ng}/R_{ng} through a least squares estimation algorithm. Equation 3 uses VM_{ng}/R_{ng} to compute the instantaneous natural gas tank mass (m_k). These equations enable calculation of the tank mass even when we do not know the exact size of the tank or the composition of the gas. By starting the App with an estimated value for VM_{ng}/R_{ng} the App will adjust this value through a learning process.

$$(c_0 - c_k)\frac{VM_{ng}}{R_{ng}} = m_{f\_consumed} \quad (1)$$

$$c_k = \frac{p_k}{T_k Z_k} \quad (2)$$

$$c_k \frac{VM_{ng}}{R_{ng}} = m_k \quad (3)$$

The data in Figure I.6.1 shows that trucks 1331, 1332, 1415 and 1590 start at a similar value for VM_{ng}/R_{ng} of 0.001975 at the beginning of the month. Truck 1416 starts at a lower value of 0.00182, which has remained constant across the data shown for the month of March 2023. The application stores the estimated values over the last 10 days and calculates the average for a given day. Figure I.6.1 shows how the App improves the value for VM_{ng}/R_{ng} as usage data is accumulated and can even adjust the value to account for trucks that have different numbers and sizes of tanks.

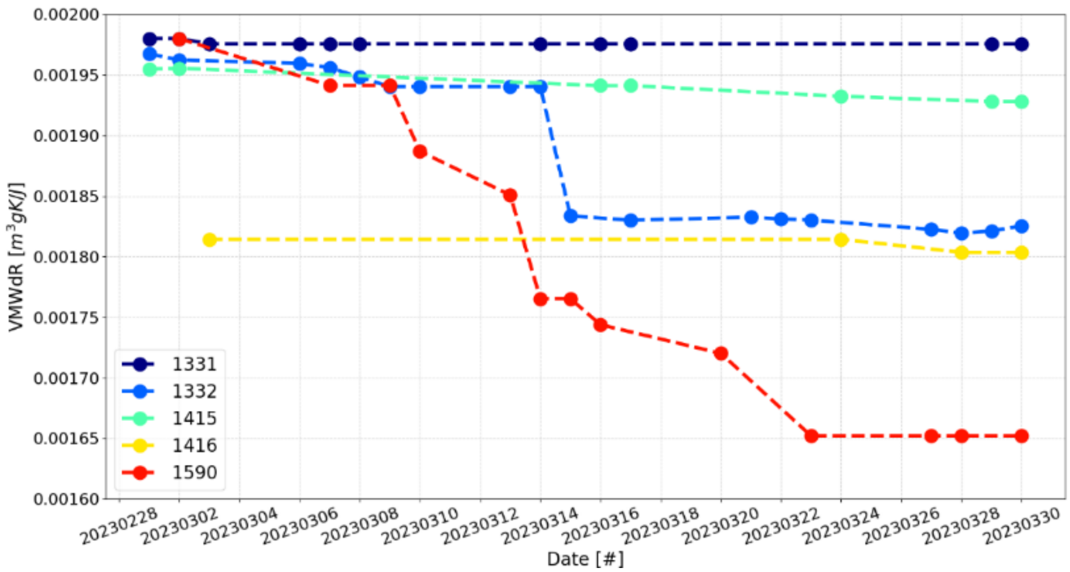

Figure I.6.1 Plot of the variation of VMWdR over time for March 2023.

Figure I.6.1 allows a comparison of trucks 1415 and 1590, which both operate out of Montgomery. Truck 1415 is equipped with two tanks, like most other trucks, in contrast to 1590, which is fitted with only a single tank. The Android app was installed on truck 1590 with an initial VM_{ng}/R_{ng} value of 0.001975. This value was found to be accurate for most two-tank systems. Figure I.6.1 shows the adaptation of VM_{ng}/R_{ng} over the following days to the smaller fuel storage volume on 1590.

The Android application utilizes an algorithm that predicts the range of distances a vehicle can travel based on the estimated tank mass and vehicle efficiency. To evaluate the accuracy of the algorithm, Figure I.6.2 and Figure I.6.3 compare the predicted ranges with the actual distance driven for the two selected trucks, 1415 and 1590. The algorithm calculates the mean distance-to-empty and the upper and lower bounds, which are based on computed standard deviations of the vehicle efficiency over the past 10 operating days. All predicted distances (upper limit, mean and lower limit) in Figure I.6.2 and Figure I.6.3 are displayed with respect to their initial value at the beginning of the day.

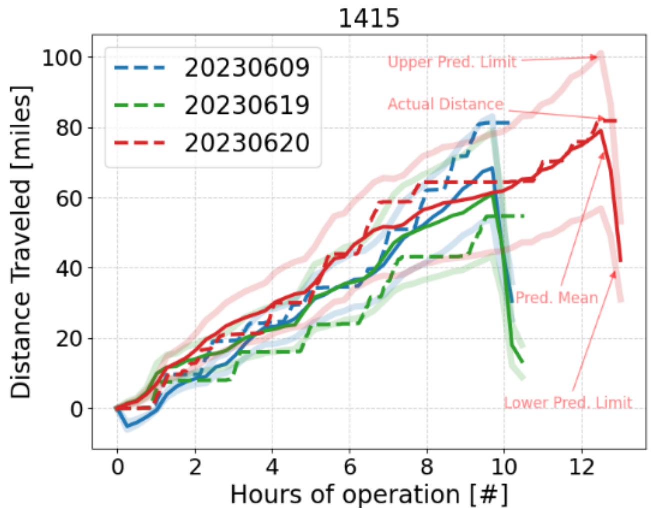

Figure I.6.2 Estimated and actual distances driven versus hours of operation for truck 1415.

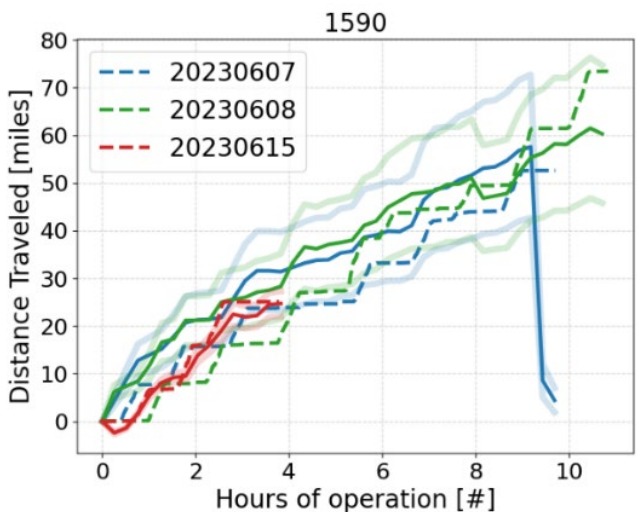

Figure I.6.3 Estimated and actual distances driven versus hours of operation for truck 1590

In Figure I.6.2 and Figure I.6.3, the dashed lines represent the actual distance driven, obtained from the vehicles' CAN buses. The light-colored traces indicate the upper and lower boundaries of the 2σ confidence interval, while the continuous line reflects the predicted distance with respect to the predicted distance shown at the beginning of the day when the truck was first started up. For truck 1415, it is shown that the predicted mean distance (solid line) and the actual distance driven (dashed line) show good agreement most of the time. The algorithm had estimated the correct tank mass and gas properties for truck 1415. Looking at the right graph for truck 1590, the data from June 7 and 8, 2023, suggest that there is a significant difference between the predicted mean distance (solid line) and the actual driven distance (dashed line), especially within the first few hours of operation. This can be attributed to the fact that the initial tank properties are set for two tanks while 1590 has a single tank.

However, by June 15, the underlying values utilized for the distance to empty estimation are closer to the true values, compared to the beginning of the month, and thus the data for June 15 shows better agreement between prediction and actual distance. Of note are the dips below zero that can occur within the first hour of operation. This can be attributed to changes in temperature and pressure in the tank right after start-up that led to slightly more estimated tank mass than when the engine was first started up, leading to a slightly higher DTE prediction.

Implementation of the Distance-to-Empty Estimation Algorithm

Figure I.6.4 exhibits the upper and lower limit of the estimated DTE in blue as well as the mean value in red across one single day for truck # 1416. The colored traces (blue and red) in Figure I.6.4 are the filtered plots of the actual estimated values (gray). Filtration is required because spikes are observed in the estimated DTE values stem from a bad connection of one of the two available temperature sensors in the tank, which directly influences the estimation of the tank mass and DTE. The Android application was initialized with average historic values for VM_{ng}/R_{ng}, reflecting the tank size and gas property estimate, as well as for fuel efficiency and the standard deviation thereof. Having VM_{ng}/R_{ng} available allows an estimate of the natural gas mass in the tank. Utilizing this with the fuel efficiency and the standard deviation allows calculation of the mean DTE estimate and the upper and lower limit of DTE, reflecting a 2σ (or 95%) confidence interval. The Android application is initialized with the average value of the last 10 days for the parameters mentioned. New estimated values at the end of the day are saved locally on the phone and will affect the average parameter values the next time the application is initialized.

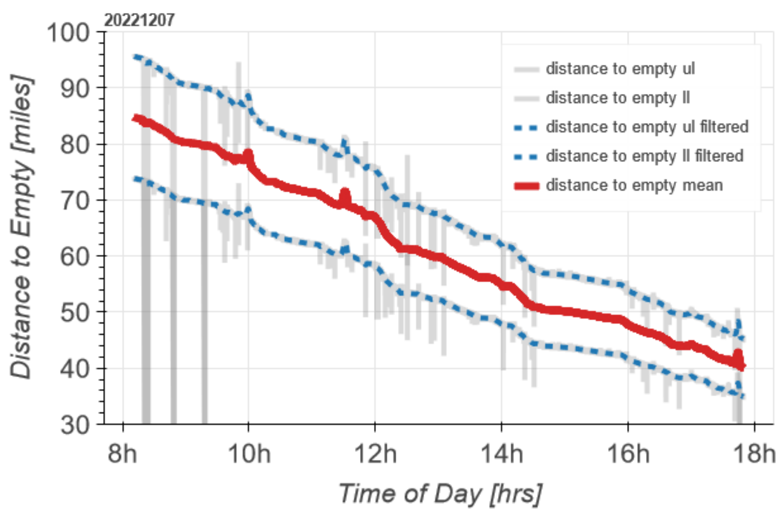

Figure I.6.4 Distance to empty estimates across one single day. The blue traces reflect the upper and lower estimates (2σ confidence interval) while the red traces show the mean value.

Figure I.6.5 compares the predicted DTE and the actual traveled distance across a single day. The initial mean DTE estimate at the beginning of the day (initial value of the red trace in Figure I.6.4) was set as the reference and the remaining mean DTE value was subtracted from that across the day. The mean value is shown in red while the upper and lower estimates (2σ confidence interval) are shown in blue. The actual distance covered as a function of time is shown in black.

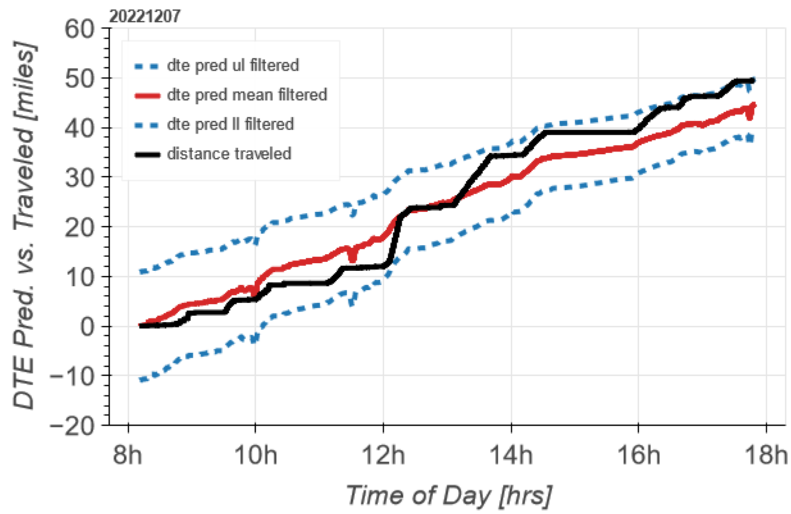

Figure I.6.5 Comparison of predicted distance to empty and traveled distance. The blue traces show the upper and lower limit of distance to empty with the red line reflecting the mean value. The black trace reflects the actual distance travel.

For this given day, the distance traveled was close to the lower limit of the DTE estimate in the morning and changed course around noon to approach the upper limit. The reason for this behavior is based on the duty cycle for this specific day. The truck covered little distance in the morning with significant idling times (horizontal sections in black trace). While significant idling periods can also be seen in the afternoon, the truck spent a substantial amount of time at higher speeds, in this case on the highway, with the engine operating under more efficient conditions than one would encounter in stop-and-go traffic. At the end of the day around 6:00 PM the accumulated distance traveled was close to the upper limit of the estimated DTE.

Methods to Display DTE Results

GTI and ANL worked with Ozinga Brothers on how to display the DTE information in the vehicles. After deciding to use the existing phones as displays rather than separate gauges, this effort focused on designing and fabricating a case that can be mounted on the dashboard for easy viewing and enhanced cooling while restricting driver access to the phone. Because of uncertainties in determining a truck's average speed and the tank's remaining fuel mass, a range of DTE values is displayed rather than a single value. The DTE range can be adjusted based on actual fuel economy computed as a function of recent driving conditions. This is demonstrated in Figure I.6.6. The values displayed on the fuel gauge represent DTE values based on different driving scenarios. The App keeps track of fuel consumed and distance covered, and this information is used to calculate the covariance in fuel efficiency. Multiplying the remaining fuel mass by the average fuel efficiency per distance traveled results in the bold number in the middle, 156. The top number, 215, illustrates a driving scenario in which the fuel efficiency is one standard deviation above the mean, while the number at the bottom, 98, reflects a driving scenario with fuel efficiency one standard deviation below the historic mean. The algorithm adjusts to parameter changes that occur, such as changes in gas properties, driving behavior, or duty cycle.

Figure I.6.6 Distance to empty interface showing upper, mean, and lower values. The indicator on the left side illustrates vehicle efficiency while the indicator on the right shows tank mass.

The entire assembly, consisting of a Google Pixel 4a phone, phone case, and a fan (shown on the left in Figure I.6.7) were installed in 12 trucks, as illustrated in the photo on the right in Figure I.6.7.

Figure I.6.7 Left - 3D printed phone case and phone displaying the fuel gauge. Right - First installation of assembly in a ready-mix concrete truck is highlighted by the yellow dashed circle.

Deployment

The next step in the development of the Driver Information System is the commercialization of the system. For this to occur, the system needs to have two advancements:

1. A component is needed to place a temperature sensor in the end of a CNG vessel opposite the fill valve. This component, likely a modified end plug, must have the Duetsch connection for the temperature sensor as well as a port for connection of the temperature relief device often connected to this opposite end of the tank.

2. The Driver Information System algorithm needs to be housed either in an Electronic Control Unit in the vehicle or in some other device.

For an initial deployment, we have decided to design and fabricate an end plug that has temperature measurement and relief capabilities. We currently have an initial design and are finalizing details for the electrical pass-through and temperature sensor. Ozinga has also presented a realistic path for early deployment: to integrate the algorithm into Ozinga's existing fleet dispatch software. This will allow the calculations to be housed in a cloud-based system that can be modified in a central location if needed. Once the algorithm is proven out, work will begin to integrate the calculations into Ozinga's fleet dispatch software.

Conclusions

GTI and its partner, ANL, have confirmed that more accurate estimations of usable remaining fuel and miles-to-empty for NGVs are possible if well-defined information about CNG pressure and temperature is known. On this project, GTI and ANL developed the models to make these predictions and tested them against real-world data in a wide range of duty cycles and weather conditions. GTI and ANL installed the models and data acquisition systems and tested them on twelve trucks to determine whether a simple, cost-effective system can provide NGV drivers with the information they need to calculate fuel economy, estimate remaining fuel on board, estimate DTE, and overcome range anxiety. During the last portion of this project GTI will collect driver feedback on the utility of the systems and will work on deployment and commercialization.

Acknowledgements

GTI would like to acknowledge the technical contributions of our partners at Argonne National Laboratory, Dr. Thomas Wallner and Dr. Michael Pamminger. We would also like to acknowledge the participation of our industry partners, Mr. Jeffrey Bonnema of Ozinga Brothers, Inc. and Ms. Samantha Bingham and John Walton of the Illinois Alliance for Clean Transportation, formerly the Chicago Area Clean Cities Coalition.

I.7 The Clean Rural Shared Electric Mobility Project (Forth)

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Start Date: October 1, 2019 End Date: June 30, 2023
Project Funding: $1,054,020 DOE share: $548,540 Non-DOE share: $605,480

Project Introduction

Forth is a nonprofit whose mission is to advance electric, smart, and shared transportation through demonstration projects, policy advocacy, and engagement. There is tremendous potential to benefit from supplemental mobility services such as electric carsharing, such as cost savings, increased accessibility, reduced congestion, and reduced environmental impact. However, due to low population density, lack of charging infrastructure, lack of familiarity with carsharing or electric vehicles (EVs), and longer driving distances, carsharing has not been well-established in rural communities. The Clean Rural Shared Electric Mobility Project (CRuSE) introduced an all-electric carshare program in Hood River, Oregon. The carshare, consisting of five electric vehicles placed with dedicated electric vehicle charging stations at five distinct sites, provided several groups of users with access, including City employees, affordable housing residents, tourists, and the general community population.

Objectives

The objective of this project is to develop, demonstrate, and refine an affordable, accessible, sustainable, and replicable financial model for electric carsharing in rural Hood River, Oregon. The overall project goals of the CRuSE Project are to demonstrate that round-trip EV carsharing can serve rural communities – including low-income residents – effectively and financially sustainably; and to develop the tools and voice to educate, encourage and replicate carsharing in other rural communities. Critical success factors will include the CRuSE project's ability to (i) entice Hood River's low-income residents, government, businesses, townspeople, and tourists to first try, then grow, their carsharing use; (ii) obtain qualitative and quantitative data from users, and on operations and revenue streams, so data analytics can inform our understanding of what is/is not working, leading to ongoing design improvements and the development of a replicable, financially viable model; and (iii) encourage other rural regions to implement similar carsharing projects.

Approach

The CRuSE Project seeks to significantly reduce many upfront cost challenges and other barriers to EV carsharing deployment at five sites in Hood River to achieve the following targeted improvements:

- Initiate and grow EV carsharing usage among each of three market segments (i) low-income residents, (ii) business, government, and townspeople, and (iii) tourists, over the 3-year project period, with data and feedback from user surveys, operations, and economics, to enhance understanding and inform iterative project refinements.
- Document EV carsharing's energy efficiency, air quality, and greenhouse gas benefits.
- Enhance Envoy Technologies' carsharing app to increase accessibility for low-income residents via:

    - Spanish language translation of the software application.
    - Tiered pricing structure, creating an opportunity for subsidies to qualified users.
    - Alternate payment mechanisms to increase access for unbanked individuals.
- Identify key success factors and develop a financially sustainable carsharing model.
- Produce and document best practices through interim reports and a final case study.
- Encourage replication in other rural communities through webinars and workshops.
- Provide hands-on technical assistance to help three other rural regions around the country to implement similar carsharing projects in partnership with local Clean Cities coalitions.

Project Lifecycle

The first year and Budget Period of the project consisted of initiation and project launch. This included site assessment and selection for charging station installation; preparation of each site with an installed charging station and vehicle; outreach and education to the community about the program; technology upgrades to the software app; and data collection through surveys and charging and travel behavior.

Budget Period 2 consisted of project refinement, continued outreach and marketing, additional technological upgrades to the app, and initial assessments of the model's financial viability.

Budget Period 3 consisted of final project refinements, continued outreach and marketing, additional technological upgrades to the app, refining the financial viability model, and producing a final case study.

Partners

For this project, Forth partnered with a number of local and national partners to fulfill its deliverables and objectives, including Envoy Technologies, Pacific Northwest National Laboratory, Columbia-Willamette Clean Cities Coalition, American Honda, OpConnect, Pacific Power, City of Hood River, Port of Hood River, Columbia Cascade Housing Corporation, Mid-Columbia Economic Development District, Columbia Area Transit, and Ride Connection.

Results

Budget Period 3 began on July 1, 2022, and continued through the project's conclusion on June 30, 2023. During that period, project work was focused on the following milestones.

- Project Refinement
- Data analysis
- Provision of Technical Assistance to Clean Cities Coalitions
- Dissemination of Project Findings.

Project Refinement

Below are some strategies and accomplishments related to deepening this engagement, spreading awareness, and refining the service. Tactics included:

- Envoy made two longer-range vehicles, Chevy Bolts, available for this program in February 2023. These vehicles replaced two Nissan Leafs that were already existing in the fleet. Forth and Envoy determined the best place to incorporate the vehicle swap would be at the most highly utilized sites in the program, the public-facing Columbia Lot and Waterfront locations.

- In January and February 2023 Forth visited Hood River and disseminated flyers at local businesses, restaurants, and public spaces to help spread the word about the program, emphasizing the recently reduced pricing.
- The team applied customized Spanglish bus advertisements with Pageworks Design to two different Columbia Area Transit buses. See Figure I.7.1.
- Through a partnership with The Next Door Inc., the team updated outreach materials with Plain Language and Spanish translations and used these materials at an in-person outreach event at the Wyeast Community Room. There were also demos of the vehicle, which was parked right outside of the room.

Figure I.7.1 “Spanglish” Ads for Carshare Service

Data Analysis

The primary objectives of the data analytics initiatives associated with the CruSE project encompass gaining insight into carsharing patterns and user behavior, evaluating the program's economic aspects, and quantifying emissions reductions. The Pacific Northwest National Laboratory has concluded its analysis by compiling a comprehensive final report summarizing the outcomes of the entire project. Table I.7.1 highlights the key results from the project's final year across all sites, providing a consolidated overview. This table includes essential metrics such as the total number of member bookings, the corresponding revenue generated from those bookings, and energy consumption associated with the project.

Table I.7.1 Key Results –July 2022 - June 2023

	July - Sept. 2022	Oct. - Dec. 2022	Jan. - March 2023	April - June 2023
Number of Bookings	51	71	95	113
Total Revenue	$153.35	$255.35	$501.09	$1907.55
Energy Consumed (kWh)	802	570	681	2052
GHG Savings (lbs. of CO_2)	1198.8	848.6	1007.4	3037.6

Utilizing the Envoy bookings data, we first evaluated the fluctuating numbers of monthly bookings as shown in Figure I.7.2. This bar graph illustrates that the usage and popularity of services have increased with time. Overall, we observed an increase in bookings over all five charging locations. Additionally, our analysis identified a seasonal trend in the data, revealing a consistent increase in booking numbers during the summer months and a relatively lower occurrence during the winter and spring months. These observations were particularly prominent in the case of the Fire Station and Water Front locations, where we noted a combination of seasonality and a discernable upward trend in the number of bookings. In Rio Bella's context, while the seasonality remains unclear, the upward trend persists.

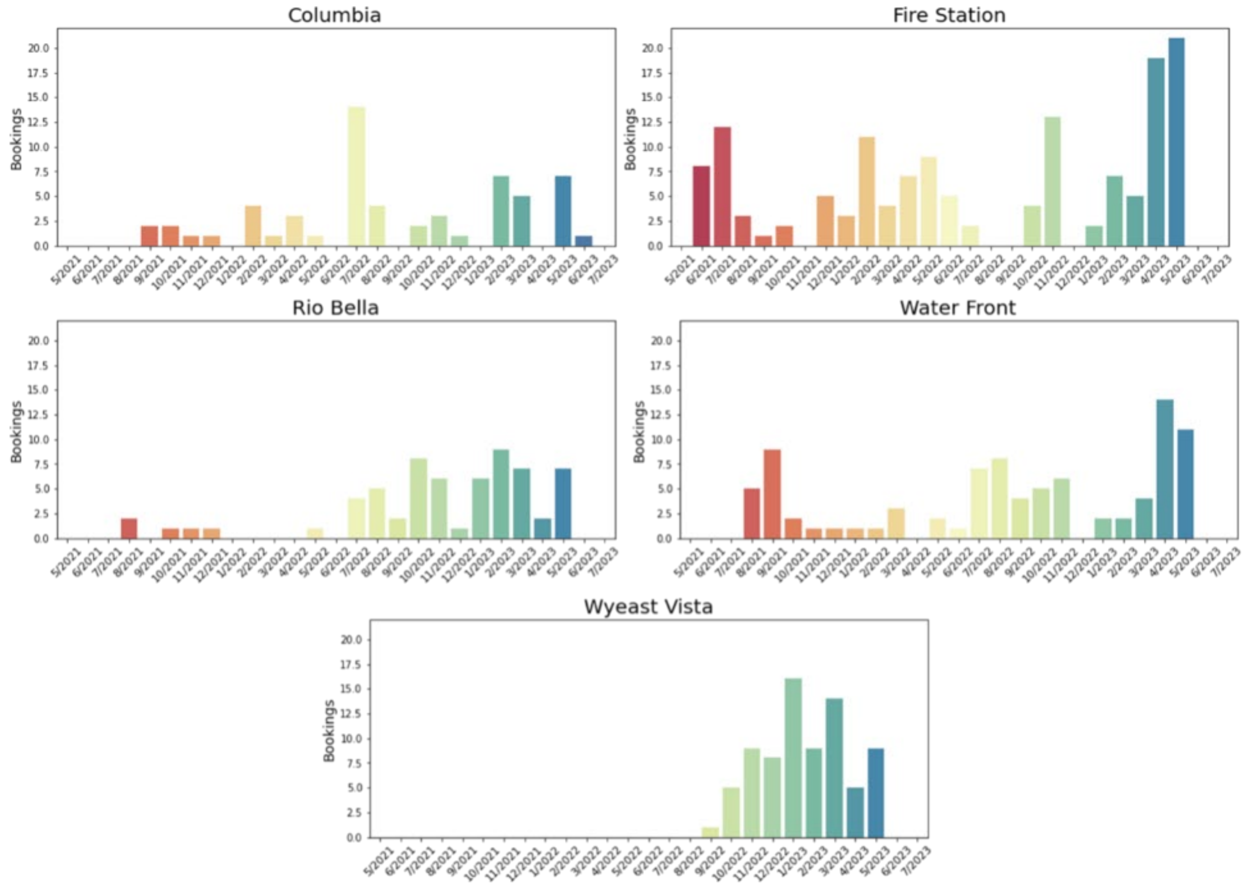

Figure I.7.2 Number of Bookings Across All Site Locations

The following section discusses data analytics from resident survey results at the Wyeast Villa and Rio Bella sites, with 29 total participants out of a total of 50 apartment units (i.e., 58% participation). Forth administered this survey in both English (i.e., 13 of 29 or 44.8%) and Spanish (i.e., 16 of 29 or 55.2%) with support from outreach partners at The Next Door Inc. Some of the participant responses are:

- 72% borrowed at least one car.
- 95% did not know anything or very little about all-electric cars.
- 48% had not heard of carsharing.
- 72% were willing to rent a carshare vehicle at <$5 per hour, 21% at $5-$10 per hour, and 7% at $10-$15 per hour.

Additionally, participants used the carshare vehicle for various reasons, as shown in Figure I.7.3.

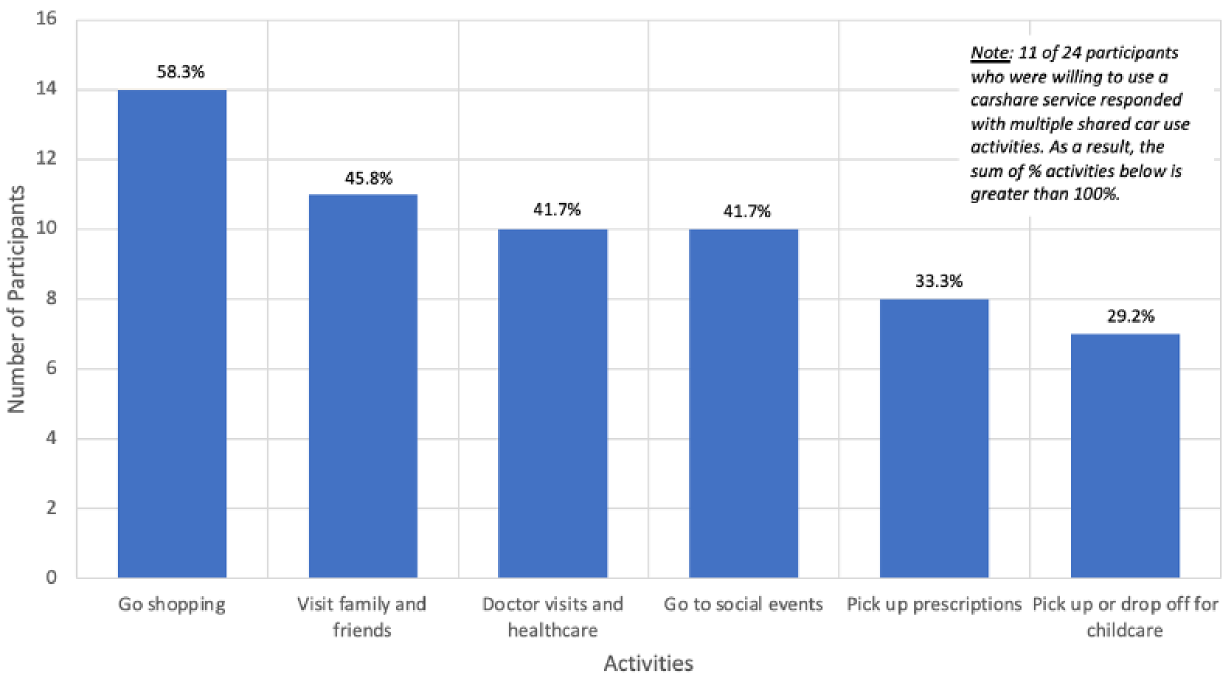

Figure I.7.3 Carshare Vehicle Uses

Provision of Technical Assistance to Clean Cities Coalitions

During this period, Forth continued meeting with two partners, Columbia-Willamette Clean Cities Coalition and Ride Connection, to continue implementation on end-of-project activities. First, Ride Connection completed its work to compile lessons from CRuSE and other best practices for implementing EV carsharing into a final case study. Columbia Willamette Clean Cities Coalition has supported this project by disseminating project results to other Clean Cities Coalitions based on past participation of certain coalitions in Columbia-Willamette Clean Cities Coalition's Mindful Mobility Tech Talks and the Green Transportation Summit and Expo. The list of Clean Cities coalitions reached exceeds the metric of three coalitions outlined in the SOPO:

- Capitol Clean Cities of Connecticut
- Yellowstone-Teton Clean Cities Coalition
- Drive Clean Colorado (formerly Denver Metro Clean Cities)
- Northern Colorado Clean Cities Coalition
- Long Beach Clean Cities
- Arkansas Clean Cities
- Vermont Clean Cities
- Greater New Haven Clean Cities Coalition

Dissemination of Project Findings

- Participated in a speaking engagement with the Hood River Energy Council on a webinar, EVs for Everyone, on November 9, 2022, with about 40 stakeholders present.
- Presented about the carshare project to the Hood River City Council, coordinated by our contact at the City of Hood River. We received positive feedback from both the Council and others present.
- The CRuSE Project was featured in a Mindful Mobility Tech Talk (56 attendees) hosted by Columbia-Willamette Clean Cities Coalition. Forth spoke about its experiences with the CRuSE Project and other learnings from its other carshare programs.
    - The webinar recording can be viewed at: https://vimeo.com/841386456
- Forth also showcased the CRuSE Project at the Electric Vehicle Symposium 36 in Sacramento, CA. The presentation, delivered in a dialogue style, was supplemented by a corresponding report available in the publications section below.

Conclusions

The project refinement strategies in the final year seemed to correlate with increased utilization, and the project team hypothesis utilization would have continued to increase; however, service officially ended for the CRuSE Project on June 22, 2023. Vehicles and associated signage were removed from each location by June 25, 2023. The team developed a final analysis in partnership with Pacific Northwest National Labs, examining data from the carshare and charger utilization.

The final partner meeting for the CRuSE project occurred on June 29, 2023. During this meeting, held over Zoom, Forth led a project reflection discussion to allow partners to share what they saw as successes, challenges, and opportunities throughout this project. The key takeaways are captured below.

What Worked:

- The community realized clean and accessible transportation options.
- The program made a low-cost option available.
- In-person events at resident location were successful and impactful.
- Partnerships with local organizations helped inform and drive program refinement.
- Transparency of data

Where We Fell Short:

- The project period was short; it took so long to get the program up and running and for the public to understand what it was and how to use it.
- The reservation smartphone app was unreliable and difficult to use.
- The vehicles were constantly out of service due to maintenance or dead battery issues; range was an issue before vehicles were replaced with longer range options.
- The project could have been even more accessible had we found ways for residents to use cash to purchase driving credits.

Looking Ahead:

- Future projects should capture SMARTE [Strategic, Measurable, Ambitious, Realistic, Time-bound, Inclusive, and Equitable] commitments from partners before grant funds are sought.
- Community partners want to see this program continue.
- A 2.0 project should consider more than one vehicle per site to offer redundancy for vehicle availability, a different reservation platform more compatible with the use cases for this community, in-person onboarding for users, and more visibility of the cars either through their location or branding.

Learnings and experience from the CRuSE project have also led to the growth and replication of rural EV carsharing in other regions through GoForth Carshare and another Department of Energy program to expand electric carshare around the country via the Affordable Mobility Platform (AMP) Project [EE0009864].

Key Publications

Yearick, Kelly. Herman, Connor. Zavon, Jennifer. June 2023. Community Impacts: Accessible Electric Vehicle Carshare, https://forthmobility.org/storage/app/media/Reports/Community%20Impacts-%20Community%20Carsharing%20EVS%20236.pdf

Acknowledgements

Forth would like to acknowledge and thank National Energy Technology Laboratory Project Manager Dan Nardozzi and DOE Technology Development Manager Michael Laughlin for their valuable insights and support throughout this project. We are also grateful for our many partners that together are making this project possible:

- Pacific Power
- Columbia-Willamette Clean Cities Coalition
- Pacific Northwest National Laboratory
- Envoy Technologies
- American Honda
- OpConnect
- City of Hood River, Oregon
- Port of Hood River, Oregon
- Mid-Columbia Economic Development District
- Columbia Cascade Housing Corporation
- Columbia Area Transit
- Ride Connection.

I.8 Holistic and Energy-efficient Rural County Mobility Platform (RAMP) (Carnegie Mellon University)

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Start Date: January 1, 2020 End Date: May 31, 2024
Project Funding: $2,037,781 DOE share: $1,000,000 Non-DOE share: $1,037,781

Project Introduction

Rural America, representing 97% of the U.S. land area, is home to 15% of the total U.S. population. Rural trips for commuting, shopping, health care and community-based services have become increasingly longer in the past few decades. Unfortunately, mobility services to rural areas are insufficient, inefficient, unaffordable, and inaccessible, with highly limited resources. Often rural trips are made by solo-driving in private vehicles with low fuel economy. Very little public transit or shared mobility is utilized. Those rural trips are likely to be long, expensive, with a single trip purpose, and thus energy inefficient. More importantly, because rural trips are extra burdensome to households both financially and physically, it makes resources, facilities, and other communities more inaccessible to rural populations.

Greene County is a typical rural county in Southwestern Pennsylvania bordering West Virginia, with about 39,000 in population. Waynesburg, the County seat, is home to Waynesburg University (WU), a partner with Carnegie Mellon University (CMU) in research and educational projects. Recently a group of faculty and students probed the difficult issue of food insecurity in the County. Over 13% of the county's population is food insecure, and one third of those individuals are children. The primary finding of the study focused on the transportation barriers to dealing with the issue, i.e., getting food to people or people to food.

In Greene County, 57% of households report at least one member with high blood pressure. A number of their non-emergency doctor appointments, especially among children and the elderly, are delayed or missed due to insufficient and inefficient mobility services. There is no public transit in Greene County, nor are there shared mobility services, such as taxis, Uber, or Lyft. The only mobility service available is through the Greene County Transportation Program where residents are required to book a ride in advance. The Program provided 40,323 trips in 2017, and 26% were associated with seniors. The average trip time was more than one hour, at an average cost of more than $26 per ride. A recent survey by Greene County Human Services shows there are local residents who have no other choice than to pay more than $50 for riding the shuttle into the City of Pittsburgh, the closest major city. Mobility service in Greene County is clearly insufficient, inefficient, and unaffordable, affecting access to not only healthy food, but healthcare, work, and community services.

Waynesburg University (WU) of Greene County (GC) enrolls approximately 2,500 students and offers shuttle services to transport students to and from bus and train stations outside Greene County, local hospitals, and shopping retailers. Despite students finding it a challenge to get around the City of Waynesburg, the shuttle service ridership is low and has been dropping over the past years, due to inefficient service not fulfilling student demand. WU has Bonner student volunteers (10 hours per week service for a Bonner scholarship) to drive those shuttle services, but clearly those volunteering resources could be optimally allocated to facilitate a more efficient rural mobility service.

Objectives

We propose developing a holistic approach to address the mobility challenges in Greene County, and this approach can be replicable to all rural counties in the U.S. Key will be developing a capability that does not now exist in the U.S., namely a “Rural County Mobility Platform” (RAMP) consisting of both an online platform and phone-based system to offer a comprehensive set of mobility services: trip reservations, on-demand trip request in the rural area, structured fixed-route and on-demand shuttle services, volunteer management, volunteer-request matching, and mobility information dissemination. This project will support developing methods and algorithms to pilot a new hybrid service consisting of two complementary components: a fixed-route flag-stop shuttle service system for long-distance trips and a flex-route shuttle service for short or medium distance trips (namely, a service taking riders of on-demand, advanced reservation, or walk-up, with flag stops). It will also include a new capability for more efficient data-driven operations of the existing Greene County Transportation Program and WU shuttle services. This holistic approach will primarily target four types of rural trip access: work, food, health care, and community-based services. There are three main features of RAMP that are distinct from general mobility services: a hybrid service design tailored for both long-distance rural trips and short-distance within-community trips, data-enabled matching/routing among rural riders and services, and outreach to the rural population. The RAMP system has been developed and will be effective as of November 2023, and will be piloted in Greene County thereafter.

Approach

As an initial and ongoing activity, the team engaged Greene County residents in a process of “human-centered design” to ensure that the pilots are developed with the input of the targeted clientele. On an ongoing basis, we have collected data from riders, volunteers, and shuttle services, and conducted surveys of local residents and WU students/faculty/staff, with the aim of improving the system design throughout the project. We also reached out nationally in various conferences to both share our experiences and to benefit from the experience of others addressing rural mobility issues.

Indicative of many rural counties, Greene County residents have a strong culture of volunteer service, ranging from volunteer fire departments to volunteer service by WU students (e.g., Bonner volunteer program). However, matching an individual’s need for mobility with a volunteer who is willing to meet that need is problematic and inefficient. As part of the hybrid rural mobility service, we are designing an online system to manage and check in volunteers, provide incentives, and develop a method to optimally match volunteers and pick-up/drop-off requests (for both people and goods). The proposed Rural County Mobility Platform (RAMP) would allow volunteers to report their service time windows, locations and possible routes. This will be complemented by an additional incentive program to encourage volunteers to fulfill on-demand pick-up/drop-off requests. Incentives include public acknowledgements, gas gift cards, vouchers for community shopping, free shuttle rides, Bonner scholar hours (for WU students only), etc. Not everyone in a rural area like Greene County has ready access to either internet or cell phone service. Thus, it is mandatory to design RAMP to be a landline phone-based service as well as internet and mobile phone accessible.

The hybrid mobility system designed under RAMP is analogous to hub-and-spoke networks, where the fixed-route shuttle service runs between center hubs, but on-demand shuttle services and volunteer service trips meet the demand from the main hubs to scattered origins/destinations, or between scattered origins/destinations. The RAMP system, once piloted in 2024, will collect anonymous data from both volunteers and rider requests. Those data together will be analyzed on a monthly basis to identify system inefficiencies and develop solutions to improve the hybrid service design and the online system.

Another barrier to efficient rural mobility service is the inability to adapt to incidents or events in the rural areas. Rural trips have very limited choices in routes and points of interest. If roads or points of interest are subject to planned events or unplanned incidents, trips are likely to be substantially impacted. Therefore, RAMP leverages existing data sources (from public agencies and social media, e.g., PennDOT and Twitter/Waze) to monitor traffic conditions in real-time, and then take them into account when optimizing mobility services and disseminating trip/traffic information to residents.

The performance of the mobility services is measured and optimized in terms of travel time, vehicle-miles traveled, fuel use, emissions, accessibility, affordability, and mobility-energy productivity (MEP). MEP is an emerging energy and user cost weighted accessibility metric under development at the National Renewable Energy Laboratory (NREL) that provides a mobility benefit per unit of energy. DOE's SMART Mobility team and NREL's rural-to-urban mobility dynamics team will explore the data that is collected, integrated, and analyzed for this pilot study, along with optimized models and algorithms, to identify potential replicability of analytical/modeling insights in other rural regions.

Results

The research team designed two surveys, one for faculty/staff/students at Waynesburg University (WU) and the other for the general public in Greene County. The surveys are designed to understand the mobility needs of Greene County residents, including a relatively large population of WU affiliates. This also increases awareness of how mobility service in rural communities is critical for quality of life, as well as for workforce training. The research team then conducted four focus groups on the WU campus that consisted of over 100 faculty/staff/student representatives since 2020, despite the project delay imposed by the pandemic. The team conducted three versions of sample surveys to seek comments and feedback from those potential survey responders. The team then modified and improved the surveys, made an online survey portal, and submitted it to the Institutional Review Board (IRB) for human subject research approval. The survey was formally distributed and conducted from November 2021 to August 2022. The team received and validated 450 samples from WU affiliates and 450 samples from the County general public.

The research team used the survey data to calibrate several models to analyze factors that influence the travel choice behavior of residents in the Waynesburg region that could help in improving rural mobility in the future. While the research team calibrated several individual models for residents and WU affiliates, only the results of travel choice behavior for shared shuttle use versus the existing modes for residents are presented in Table I.8.1. These results are based on a random parameters logit model that accounts for unobserved heterogeneity to avoid omitted variable bias. The variables with positive coefficients indicate a higher likelihood of using a shared shuttle while negative coefficients indicate higher likelihood towards using the existing modes. An important personal characteristic of inconvenience showed a higher propensity toward using existing modes as opposed to a shared shuttle. This is because some residents consider inconvenience a significant factor in deciding their mode of travel. Such commuters consider personal vehicles as more convenient and have childcare responsibilities and varying schedules for work that require them to move back and forth across locations, thus making a shared shuttle less attractive for them. Furthermore, men showed a higher propensity to use a shared shuttle than women in the rural area. Interestingly, this finding contrasts with past studies that observed women to be more likely to adopt shared services; however, past research has not focused on mobility choices in rural communities. Gender differences elsewhere were attributed to safety perceptions and lower licensure rates among women. The context for such differences was that women were observed to have a higher propensity to substitute shared rides for public transit at night. Such differences are minimal in the context of rural areas since rural communities are already disadvantaged in having limited mobility options.

Table I.8.1 Random Parameter Model for Residents' Behavior

Variable	Shared Shuttle
	Value (p-value)
Alternative Specific Constant	-3.114 (-6.94)
Personal Factors	
Considering Inconvenience as a significant factor	-3.158 (.000)
License	0.884 (0.068)
Socio-economic Factors	
Variable for Gender (1 if Male)	0.333 (2.09)
Income of $75,000 or higher	-1.023 (.086)
Age (35-50)	1.527 (0.000)
Trip Characteristics	
Miles driven	0.025 (0.000)
Morning peak	-0.498 (0.115)
Religious activity	0.544 (1.72)
Scale Parameters for Random distribution	
Gender	1.067 (.0028)
Religious activity	1.844 (.0364)
License	1.228 (.000)
Goodness of Fit measures	
Log likelihood at convergence LL(β)	-81.50
Number of Observations	210

Two variables related to trip characteristics, i.e., miles driven and trips for religious activity, showed an increase in propensity to use shared rides. The finding related to mileage may be attributed to the fact that a shared shuttle provides residents in rural areas with the opportunity to make multiple trips without worrying about the expenses of maintaining a personal car. Likewise, trips for religious activity are performed on specific days of the week, mostly on weekends and thus, rural residents would be interested in using the comfort of a shared shuttle for such trips. In contrast, trips for the morning peak showed a lower propensity for using a shared shuttle. This may be attributed to residents' urgency of reaching their destination for such peak hour trips. The personal characteristic involving the age range of 35-50 was observed to increase the likelihood of using a shared shuttle. Interestingly, two-thirds of the middle-aged community within the National Household Travel Survey gave up driving alone when they had some sort of medical condition. The finding related to age is intuitive since this age category includes younger to middle-aged people that are mobile and are aware of shared services. Thus, the younger population (lower end of the age range) would feel comfortable in sharing their rides in a shuttle, while the middle age population (at higher end of the 35-50 age group) could similarly have some medical conditions. The findings overall indicate the desire of the community to have a choice of mobility options to their destinations.

The team further worked with Greene County Transportation Program (GCTP) to understand what data can be extracted from the current software used by Greene County, *Ecolane*. The team has downloaded all data since 2016 and conducted some analysis to gauge its spatial and temporal coverage/resolution. In addition, we have processed the GIS map of Greene County with all road segments and identified all points of interest for trips taken since 2016. Additional points of interest were also acquired from Google Maps. See Figure I.8.1 for all points of interest.

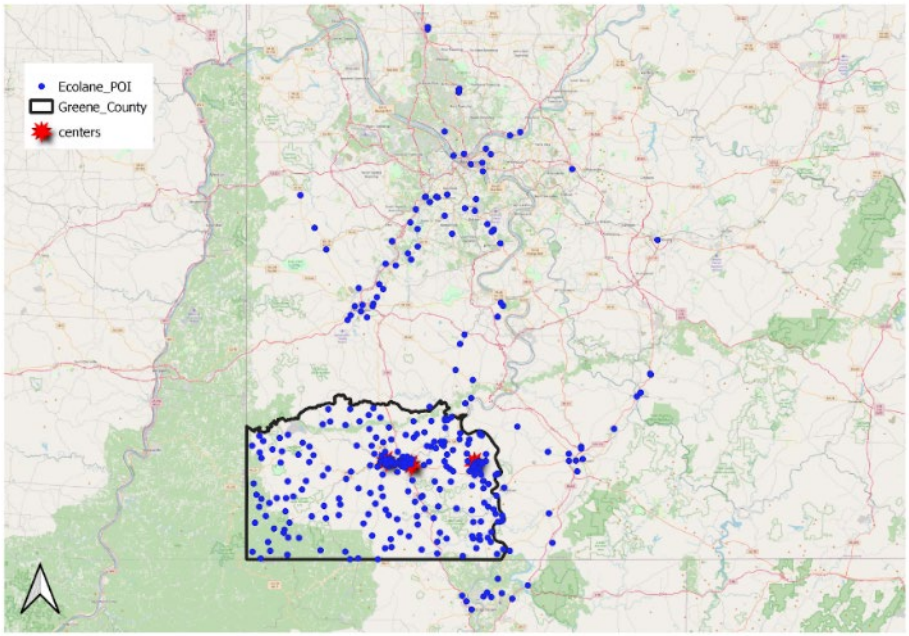

Figure I.8.1 All points of interest of trips in Greene County and three mobility hubs/centers.

The team developed an algorithm for simulating vehicle routing and demand matching for on-demand mobility service in general. The team also developed an algorithm to acquire time-varying travel time in the Southwestern Pennsylvania region and to simulate shuttle vehicle movement in the region. Based on dynamic simulation of general traffic, shuttle vehicles for mobility services, and rider requests, the team developed an algorithm to optimally assign an on-demand/walk-up rider request to a fleet of shuttle vehicles, based on status-quo and predicted rider requests. This simulation has been calibrated using *Ecolane* data and survey data. The team recently published two research papers on this model (Grahn et al., 2021, Grahn et al., 2022), and one paper is under review. The model is generally applicable in any rural/suburban area or region with low demand density and has been implemented for the overall Greene County – Allegheny County regional network.

Based on the simulation and optimization model, the team developed a hybrid mobility system for Greene County. The system is designed to be demand responsive point to point. The team has completed designing a highly structured shuttle service in partnership with WU and the Greene County Department of Human Services. Primary destinations for work, shopping, health care and community services (also known as points of interest) are selected through interviews, surveys, and data collection, and further mapped along with residential patterns. With community input and using GIS mapping capabilities, we proposed three potential main points of interest, also known as hubs (see Figure I.8.1), along with three fixed routes with daily trips scheduled between those hubs extending to outside Greene County (see Figure I.8.2). Routes are fixed in terms of schedules and planned routes/hubs but are flexible in terms of making actual stops along the route (also known as flag stops) on a daily basis. Those fixed routes are designed to carry riders for long-distance trips within the County and to/from adjacent cities (Morgantown, West Virginia, Washington, Pennsylvania, and

Pittsburgh, Pennsylvania). This shuttle service differs from conventional public transit buses since it will require riders to confirm the trips in advance via RAMP, and the shuttle can pass by (or skip) stops/hubs if not requested by riders in advance. In addition, those fixed routes are supplemented with on-demand circulator shuttles. Each hub is equipped with several circulator shuttles which are responsible for taking on-demand or walk-up demand for short-distance trips within the County, from their requested pick-up locations to either the requested destination or the most relevant hub connecting to fixed route transit.

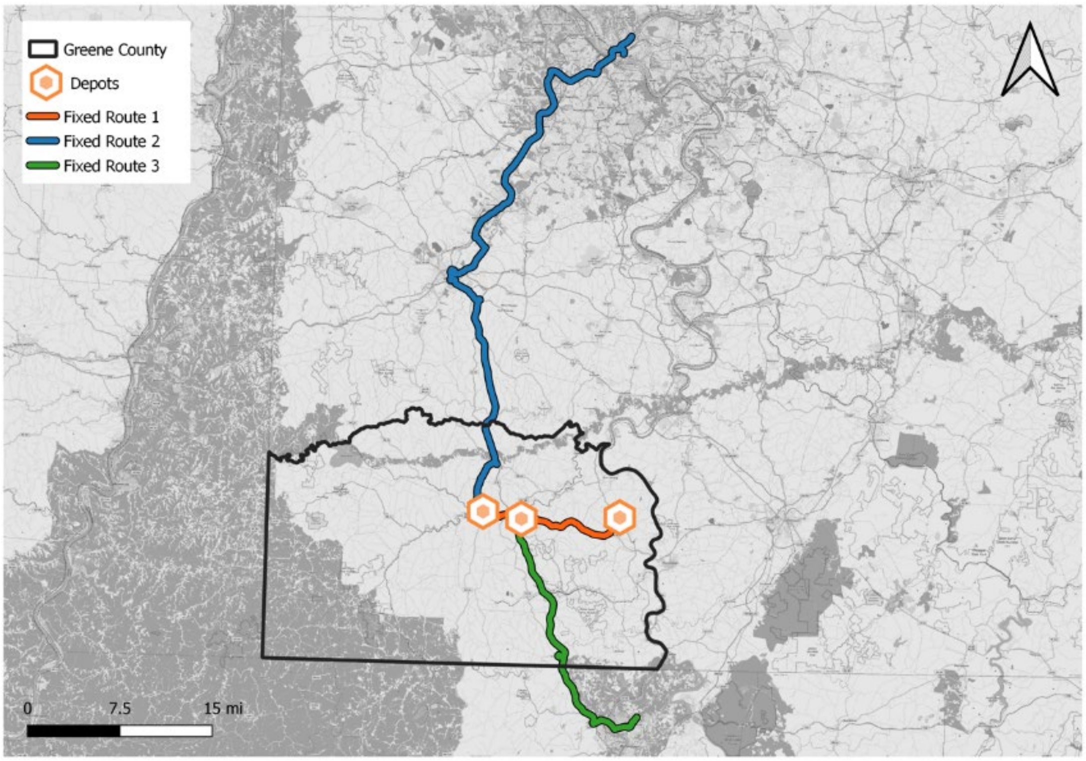

Figure I.8.2 Three mobility hubs in Greene County and three fixed routes

The team conducted several simulations of the hybrid model to analyze the performance of the proposed mobility service. A total of nineteen scenarios were generated consisting of a baseline with no fixed route or on-demand service, with different number of fixed-route services, flex-route services, geographic coverage, and demand patterns. Scenarios A1/A2/A3 are set with no fixed route and 3/6/9 on-demand shuttles, respectively, serving GCTP's current demand. Scenarios B1/B2/B3 are set with no fixed routes and 3/6/9 on-demand shuttles, respectively, serving within Greene County, and adjacent counties. Scenarios C1/C2/C3 have no fixed route and are provided with 3/6/9 on-demand shuttles, respectively, for the extended Greene County that serve a full set of future demand; Scenarios D1/D2/D3 have three fixed routes and 3/6/9 on-demand shuttles, respectively, serving the extended Greene County and future demand, Scenarios E1/E2/E3 have one fixed route only and 3/6/9 on-demand shuttles, respectively, serving the extended Greene County and future demand; Scenarios F1/F2/F3 are set with three fixed routes with 3/6/9 on-demand shuttles, respectively, serving the extended Greene County and future demand, with significant incidents on highways. The results for service rate with mobility services operating in different scenarios are provided in Table I.8.2. The baseline scenario represents the status quo in Greene County, namely GCRP services without a fixed route or on-demand service operate in this scenario, while on-demand services are added to scenarios A1 through F3.

Table I.8.2 Service rate for each scenario

Scenario	Service rate (%)
Baseline	100.0
A1	67.0
A2	71.6
A3	71.6
B1	67.0
B2	73.1
B3	73.1
C1	25.8
C2	46.4
C3	52.3
D1	53.5
D2	83.8
D3	96.5
E1	35.8
E2	71.9
E3	93.4
F1	53.3
F2	84.2
F3	95.5

It should be noted that service rate refers to the percentage of requests served as a function of total requests received. The service rate was observed to be 67% for scenario A1, revealing that most GCTP requests can be handled by on-demand services. The infeasible requests are mainly caused by origin or destination locations that are outside the county. Scenarios A2 and A3 had similar settings as scenario A1, except with a higher number of shuttles assigned to these scenarios. These scenarios revealed a higher service rate, indicating that three shuttles are sufficient to serve the within-county GCTP requests. Scenarios B1-B3 showed similar service rates in the range of 67%-73.1%. Furthermore, the service rate dropped to 25.8% for scenario C1, implying that three shuttles were insufficient to serve the full demand of those who desire to travel inside and outside the County. With more shuttles assigned to each depot (the central location for shuttle dispatch and parking), the service rate increased to 46.4% and 52.3% for scenarios C2 and C3, respectively. Fixed-route services are added to scenarios D1 through F3. The service rate was 53.5% in D1, which is 1.2% higher than that of scenario C1. The three fixed routes contribute to the increment of the service rate. The service rate further increases to 96.5% in Scenario D3, implying that nine shuttles associated with the three proposed fixed routes are sufficient to serve nearly all passengers in the extended service area. The service rate was observed to drop to 35.8% in scenario E1 with only longest fixed route, which is around 18% lower than that of scenario D1. The service rate increased to 93.4% in E3 with the addition of nine shuttles, which is close to that of scenario D3. The system performance under incidents was studied in scenarios F1, F2, and F3 and observed to be lower compared to other scenarios.

During the pilot in spring 2024, the team will install GPS sensors and dashboard cameras on the shuttles to collect service data, ensure passenger/driver safety, and collect information on road conditions. The team has developed a software toolkit that implements the models and algorithms developed in this project to optimally match rider requests and shuttle/volunteer services, optimally route vehicles for pick-ups and drop-offs, and provide performance metrics for the mobility services in general. The software provides portals for shuttle drivers, riders, system managers and volunteers, respectively. It is anticipated that the software will be tested in a pilot study in Spring 2024 for a period of three months in partnership with Blueprints (a local non-profit organization), GCTP, WU, and the Greene County Commissioners' Office. Several other local non-profit organizations are also engaged and subcontracted under WU to assist with this pilot program. It is the team's goal to pilot the RAMP system, including both modeling and service software, in other rural and suburban areas, and ultimately commercialize this system.

Conclusions

This research advances the technology and practices of mobility services in rural areas in the following aspects: a holistic rural transit mobility system addressing the citizens' needs, energy efficiency, a data-driven modeling approach, and MEP-based management. A door-to-door service in rural areas would be very expensive because not many users have the same origin and destination, but the RAMP system can provide the first/last-mile connectivity or other flexible mobility services at a high level of service. Volunteers with non-monetary incentives keep the costs low and ensure the availability of drivers locally. We propose to leverage the certainty of fixed-route transit and a critical mass of demand in several clusters by having fixed stop locations (or hubs) for the shuttle service, determined by identifying common use patterns from rider surveys using data-driven methods. The RAMP system consists of service optimization models and a set of software that supports this rural mobility service. The system will collect anonymous data from both volunteers and riders, once under pilot. These data will be analyzed to identify system inefficiencies, and to develop solutions to improve the hybrid service design and the RAMP system. Tailored specifically for rural counties (as well as for suburban areas with low trip densities), the hybrid system utilizes information technology and system-level optimal design to balance its operational cost and service efficiency/quality.

The new rural mobility service design incorporating rural travel demand characteristics and multi-source data has great potential to be widely deployed in practice for agencies that are responsible for providing rural mobility services. After the completion of this project, the team plans to transfer the technology to further develop and deploy rural mobility systems in other rural regions.

Key Publications

Grahn, Rick, Sean Qian, and Chris Hendrickson. "Improving the performance of first-and last-mile mobility services through transit coordination, real-time demand prediction, advanced reservations, and trip prioritization." *Transportation Research Part C: Emerging Technologies* 133 (2021): 103430.

Grahn, Rick, Sean Qian, Chris Hendrickson, (2022) "Optimizing first- and last-mile mobility services using transportation network companies (TNC)", Transportation.

Khattak, Z.H., Qian, S. Shared use travel behavior for improving rural mobility: A case study of Greene County, Pennsylvania. Accepted for presentation at *103rd Annual Meeting of Transportation Research Board, 2024.*

Khattak, Z.H., Gui, B, Qian, S. Hybrid structure mobility service with flex route and fixed route on-demand mobility: A network simulation-based design and assessment. To be submitted, 2023.

I.9 R.O.A.D.M.A.P: Rural Open Access Development Mobility Action Plan (Rural Action)

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Project Funding: $1,782,603 DOE share: $880,724 Non-DOE share: $901,879

Project Introduction

Rural communities are disproportionately impacted by current gaps in the transportation system, which limit access to opportunities such as healthcare, jobs, and social services. There is also a high concentration of poor, elderly, and zero-vehicle households in rural areas. Current mobility gaps plaguing rural communities include insufficient rural public transit operations; insufficient countywide affordable services; limited non-emergency medical transportation (NEMT) providers available to the public; and limited weekend, early morning, and late-night services.

The R.O.A.D.M.A.P. project aimed to better understand how advanced vehicle technologies function in these rural settings, and to enhance awareness of innovative solutions with the potential to fill transportation gaps sustainably. Rural Action led a project team that consisted of Clean Fuels Ohio (CFO), The Transportation Research Center, Inc. (TRC), Hocking Athens Perry Community Action (HAPCAP), and The Ohio Department of Transportation's (ODOT) DriveOhio Initiative. Additional partners included the City of Athens, Ohio, Columbus Yellow Cab, regional Clean Cities coalitions, the Joyce Foundation, and the Southeast Ohio Public Energy Council.

Objectives

The objective of R.O.A.D.M.A.P. was to develop, demonstrate, and refine affordable, accessible, sustainable, and replicable mobility service-enabled electric vehicle (EV) shuttle service applications in rural Appalachian Ohio. The team analyzed data from several deployments of electric and automated vehicles across transit and private vehicle operations and developed insights that informed the team's Rural Mobility Action Plan.

The National Renewable Energy Laboratory (NREL) is a key end user of the data and reporting generated by R.O.A.D.M.A.P. The project also aimed to share best practices, lessons learned, and infrastructure recommendations with a variety of other stakeholders, to accelerate rural adoption of advanced and sustainable mobility solutions in Ohio and nationwide.

Approach

The objectives of R.O.A.D.M.A.P. are supported through data collection, analysis, sharing, and public dissemination of results. The project was carried out over several interconnected task areas:

Task 1: Individual Motorist Data

Led by CFO, the partners worked to better understand the unique characteristics of rural EV owners and the rural market for EV sales and service. Data sources include the Ohio Bureau of Motor Vehicles, local EV driver clubs, and regional dealer networks. Insights gleaned can be used to help guide future infrastructure planning and incentive programs.

Task 2: EV Shuttle Pilot

HAPCAP conducted this pilot with technical assistance from other partners. It has gathered data from field tests of a battery electric shuttle bus purchased as part of the project, operating in a rural public transit fleet, Athens (Ohio) Public Transit. Following a driver and maintenance training program, the shuttle has been deployed daily in all seasons on a mixed urban/rural route, and the team used data from vehicle telematics and maintenance to evaluate its performance against a baseline supplied by existing gasoline-powered vehicles in the fleet.

Task 3: Transportation Service Provider (TSP) Analysis and Education Program

CFO and Rural Action developed a program for education and technology transfer between TSPs with EV experience and TSPs seeking to add EVs to their operations, as well as providing local Electric Vehicle Supply Equipment (EVSE) infrastructure support in the project territory. This task spanned participant recruitment, presentations, and breakout sessions at a range of clean transportation conferences, a series of ride and drive events, and peer-to-peer mentorship.

Task 4: Automated Vehicle (AV) Feasibility Study

TRC deployed an EV equipped with commercially available automated driving capabilities under a variety of rural seasonal and roadway conditions. TRC chose a Tesla Model 3 sedan equipped with Tesla's Navigate on Autopilot feature for testing, assumed to display SAE Level 2 autonomy. Controlled environment testing at TRC's facility in East Liberty, OH informed formal test planning, and was followed by a series of test deployments on a fixed rural loop in Athens County. Results of testing will help inform state and local government infrastructure strategies for enhancing automated driving adoption.

Task 5: Outreach

This task compiled and disseminated the information gathered. R.O.A.D.M.A.P. had a Project Advisory Committee with membership from Clean Cities coalitions in Kentucky, Ohio, Pennsylvania, Virginia and West Virginia, and shared progress regularly through a series of events hosted by the Appalachian Clean Transportation (ACT) Forum, a complementary outreach initiative administered by Rural Action and funded by the Joyce Foundation. Rural Action distributed final summary reports and technology transfer plans to all stakeholders at the conclusion of the project.

Task 6: EVSE Planning and Analysis

An added task for Budget Period 3, Task 6 involved partners in the following: mapping potential EVSE sites in a 5-county area that are optimal for rural charging; facilitating distribution of the DOT ROUTES EVSE Toolkit; and engaging with rural stakeholders to access funding and incentives to strategically site and install EVSE infrastructure at rural sites. In addition, Rural Action staff analyzed existing rural EVSE and station performance and usage data and uploaded datasets to NREL's Livewire platform.

Results

ODOT DriveOhio continued to maintain and provide Alternative Fuel Vehicle (AFV) data from its Ohio Bureau of Motor Vehicles (BMV) database. Rural Action and CFO held discussions on how best to utilize the additional data being provided.

Rural Action identified two avenues for further dissemination out of the discussions cited above: upload of BMV datasets to Livewire, and inclusion of more current BMV data in the final Rural Mobility Action Plan. The November 9, 2022, ceremony to unveil the EV shuttle was a resounding success. DOE representatives Michael Laughlin and Erin Russell-Story attended, with Laughlin contributing remarks during a round of speakers that also included Sarah Conley-Ballew of Rural Action, the City of Athens Mayor, and a County Commissioner.

The shuttle, fully wrapped in the design made by local Passion Works Studio, took attendees on a demonstration drive to the Athens City Pool and the site of the City's DC fast charging station. Further test rides were offered to participants as a DJ accompanied dancers in a rendition of the Electric Slide.

The Rural Action team pursued a series of informal check-ins with HAPCAP in December 2022, to stay abreast of week-to-week changes in the EV shuttle bus's deployment status. Initial shuttle data collection began in mid-November 2022, with a ramp to more regular route usage in December.

The EV shuttle is operational and has been moving from early testing to full and regular passenger-carrying revenue service; by the end of 2022, it was in daily rotation as part of the City of Athens's revenue transit fleet. The vehicle's Geotab telematics system generated raw data, and HAPCAP and Rural Action worked with the Original Equipment Manufacturer to further refine raw data into insights that meet the project deliverables.

The shuttle is employing both depot charging and top-up charging strategies, using the newly completed 19.2 kW Level 2 charger installed at the bus garage for overnight sessions and the City of Athens DC Fast Charge Station for top-up charging on route. Charging data from the DC Fast Charge station is maintained by the city and available, while Rural Action and HAPCAP staff worked to configure a dashboard provided by the depot charger's equipment manufacturer, Motiv Energy.

In addition to the data collection and analysis activities, Rural Action and HAPCAP began to explore the qualitative experience of passengers, drivers, and support staff. Among the reports that surfaced are the following perspectives:

"Two of the biggest positives so far have been the reception by our staff and the public. Our staff really enjoy driving the new bus and find it to be a fun and refreshing change of pace from our internal combustion engine (ICE) vehicles. We actually have staff requesting to get trained on it and run line 4! We have also enjoyed widespread support and engagement by the public for our vehicle. People seem to get excited about riding in it and having it be a part of their experience using Athens Public Transit (APT)."

"Reliability and maintenance has been checkered. For the bus itself, we've had three issues that needed maintenance since starting service, but only one of them seems related to the electric drivetrain specifically. We had the 12v battery fail and start off-putting gas. We've had continued issues with the rear heater, and there is an active coolant leak. For reliability, since the charging infrastructure was properly addressed, we have not had any issues. Addressing the issues with the charging infrastructure was an ongoing issue since the fall of 2022, though. If it's charging correctly and fully charged, it's really reliable so far.

Clean Fuels Ohio lost the open contract to perform fleet analyses through their partner Power a Clean Future Ohio. As a result, the Athens County fleet analysis has been paused.

The Rural Action team planned and successfully carried out the 2022 Ohio Pawpaw Festival EV Showcase, held September 17, 2022. This showcase featured the new Ford F-150 Lightning, an e-bike corral, and electrified camper vans, as well as a variety of other EVs. Seventeen owner-volunteers showed their vehicles and reported 320 engagements with festival attendees.

In partnership with Clean Fuels Ohio, Rural Action staff led planning of a major ride and drive event to mark the annual National Drive Electric Week (NDEW). The event took place Sunday, October 2, 2022, at Belpre, Ohio's Civitan Park, and featured 17 EVs including the new Ford F-150 Lightning and Kia EV6. The event had 25 volunteers, 50+ attendees and 23 people took rides or drives.

Rural Action and CFO staff helped organize Hocking Hills Cars and Coffee at the Hungry Buffalo in Logan, Ohio on November 12, 2022. This cruise-in event featured six EVs as well as 14 other cars, and around 100 attendees.

TRC completed Iteration 3 of the AV deployment study, along with all data analysis. In January and February 2023 Rural Action reviewed and provided feedback for TRC's Final AV Test Report. An excerpt from page 4 of the Executive Summary provides a high-level overview of findings:

"The study finds that rural environments offer a unique set of roadway features such as hills and curves, which can challenge the driving behavior of an AV. Rural regions can also contain a large number of low traffic gravel roads that lack pavement markings, which appear to be a crucial infrastructure element for operation of current generation AVs. Similarly, the presence of well-maintained lane-lines along curves can influence the AV's roadway departure tendencies. The study found that curvature related behavior of an AV is also influenced by driving speed on the roadway segment. Such findings were consistent regardless of the time-of-day along the route or season of data collection. However, commentary about AV performance in active adverse weather cannot be made as this is still an area of active research."

On March 16, 2023, TRC led a Project Advisory Committee meeting and presented the findings of the AV Feasibility Study for feedback. The meeting covered challenges related to lane alignment and speed recommendations, road surfaces, and blind hill approaches. Rural Action assisted with session moderation.

For the second quarter of 2023, Rural Action continued planning for a PAC meeting to review findings from the EV Shuttle Task. The meeting occurred in June 2023.

Sarah Conley-Ballew, the project Principal Investigator from 2019 – 2022, prepared for a TED-style talk, "Driving Demand to Drive Electric in Appalachia", as a capstone to her participation in the yearlong 2022 Clean Energy Leadership Institute (CELI) Fellowship. The talk took place as part of CELI's capstone showcase event held November 2, 2022.

Rural Action created a map in ARC GIS that identifies potential EVSE locations across the 5-county region. This map will be updated as new information, funding opportunities and project sites are identified, and will be posted to the ROADMAP page when completed.

In July and August 2022, the team planned a semi-annual data collection from participating charging stations and created a standardized dataset template for the first round of data collected. In September, data was formatted to the template to standardize it across charging stations. Due to historical report storage, lookback on some stations extends as far as 2019, enabling submission of a richer dataset for longitudinal analysis to Livewire.

Conclusions

In June 2023, the R.O.A.D.M.A.P. project performance period ended, and Rural Action submitted final reports to DOE in August. The ROADMAP Rural Mobility Action Plan is a comprehensive review and analysis of the project's findings, including six task-specific playbooks with recommendations for future development in each of the project areas. Key lessons learned include:

- While EV ownership in rural Appalachian Ohio is still less than half of what it is in urban counties, growth is keeping pace with that in urban areas. The gap between urban and rural adoption is not widening, at least in the area studied.

- For individual purchases, make and model preferences were similar in urban and rural areas, with sedans and crossovers dominating. While a hypothesis early in the project suggested that rural buyers might be holding out for pickup trucks to enter the EV market, it was found that after a year of two pickup models being available, pickups made up only 3% of all BEV purchases in rural Appalachian Ohio.

- Ohio counties with high EV adoption rates also ranked high for median income and urban status and vice versa. This suggests that the high price tags of today's EVs limit their attractiveness, At the beginning of

2023, the average price for a new EV was around $60,000, above the annual median income of most Appalachian Ohio counties.

- The battery electric Class 4 vehicle segment is not yet ready for all rural transit duty cycles. Routes with longer daily distances (>100 miles) may be incompatible with most models available in 2023.
- Under optimum operating conditions, the test shuttle routinely exceeded the maximum range of 105 miles listed in the manufacturer's specifications, with a fuel economy that was consistent with a 152-mile range.
- Overnight depot charging is preferable to on-route DC Fast Charging in routed service unless the fast charging station can be located at a terminal layover point; opportunistic fast charging during operation may dovetail better with demand-response service.
- Initial cost is a major point of hesitancy for small fleet owners. From small-town taxi and non-emergency medical transportation to school buses, fleet contacts reported that they were concerned about dealing with the high upfront costs and financing for EVs, even as they understood that total cost of ownership might be superior by the end of an EV's service life.
- At all events, most respondents said they plan for their next purchase to be electric, but that they would delay that purchase until they could afford it. This repeated response provides a qualitative backup to the trends observed in the R.O.A.D.M.A.P. Individual Motorist study, which found that median income was highly predictive of a county's EV adoption rate. The signs point to rural Appalachia being on board with an EV transition, economic conditions permitting.
- Several common rural road conditions caused disengagement from the Automated Driving System tested, including sharp horizontal and vertical curves (blind hills), inconsistent or absent lane markings, non-standard intersections, and unpaved roads. These disengagements occurred consistently regardless of time of day or weather conditions.
- Even in an increasingly digital age, in-person outreach and engagement have no substitute. Hands-on events such as festival tabling and ride and drives had strong interest from the public. Virtual events may struggle to attract attendance, even when topics are highly engaging.
- There is tremendous interest in new vehicle technologies in rural areas when adoption is presented based on its benefits rather than as a forced mandate. As an example, the performance and comfort features of new EV models were a consistent topic of conversation at ride and drive events, while passengers were most engaged with the ride quality and noise reduction of the EV shuttle.
- Planning for rural public EVSE installations was often a series of circles rather than a straight line. With the charging stations installed as part of the R.O.A.D.M.A.P. project, surprises connected with permits and electrical infrastructure led to multiple rounds of reevaluation and change on the way to eventual installation.
- Rural convenience stores may be ideally positioned for charging station installation. They often occupy logistically prime real estate and are already connected to source power that might permit DCFC ports. Since they already use fueling to attract customers for more lucrative in-store sales, they are primed to take station reliability seriously, and they often have the skill and resources to keep networked stations operational in a rural communications environment.

Key Publications

"ROADMAP Rural Mobility Action Plan" Michael Lachman, Streetkeys Ltd; Brandon Jones and Nikolas Merten, Clean Fuels Ohio; Mohit Mandokhot, The Transportation Research Center, Inc., August 2023.

"AV Feasibility Study: AV Deployments in Rural Environment." Transportation Research Center, Inc., August 2023.

"Athens Public Transit Electric Bus Planning: Final Report" Calstart. February 2023.

"ROADMAP: Engagement and Outreach Report" Jacob Richard, Olivia LoGuidice. February 2023.

Acknowledgements

Rural Action and the R.O.A.D.M.A.P. team are especially grateful to Michael Lachman of Streetkeys, Ltd. for his commitment and expertise in seeing the project through the final months. Other thanks go to National Energy Technology Laboratory Technical Project Officer Erin Russell-Story, NREL's Livewire team, USDOT ROUTES, and our local partners: Sustainable Ohio Public Energy Council (SOPEC) and Hocking-Athens-Perry Community Action (HAPCAP).

I.10 East Zion National Park Electric Vehicle Shuttle System Plan (EVZion) (Utah Clean Cities Coalition)

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Start Date: October 1, 2019 End Date: March 28, 2024
Project Funding: $1,436,568 DOE share: $655,000 Non-DOE share: $781,568

Project Introduction

EVZion has continued to blaze a trail in ecological innovation, proudly upholding its mission to showcase an ecologically responsible, emission-free electric vehicle (EV) shuttle system at the east entrance of Zion National Park. In the past year, this pioneering pilot graduated from its initial phase with the launch of two all-electric shuttles, underpinned by the multifaceted support of Utah Clean Cities (UCC). These early strides in demonstration have been instrumental in shaping the strategic transit infrastructure that is central to the success of the Zion National Park Discovery Center.

The project team is working with a variety of stakeholders, including Zion National Park, the Zion Mountain Local Services District (ZMLSD), Kane County, Zion Forever, Zion Regional Collaborative (ZRC), the Utah Department of Transportation, Five County Association of Governments, the Utah Office of the Governor, Utah Tourism, academic institutions, private and public entities, and Tribal communities. This network ensures that the East Zion initiatives are coordinated and that all parties are engaged in the conversation and resultant work.

Zion National Park has the largest transit system of any national park, and the project team is evaluating opportunities to improve transportation infrastructure and systems in the park and surrounding areas. This includes assessing the needs of visitor centers, transit systems, transportation hubs, gateway communities, and nearby metropolitan areas.

Entering 2023, the project's trajectory has expanded, driving integration with advanced Electric Vehicle Supply Equipment (EVSE) and diving deeper into data analytics. In partnership with the National Renewable Energy Laboratory (NREL), the team is analyzing EVZion shuttle performance data and fostering robust vehicle-to-Original Equipment Manufacturer (OEM) communication.

The project's commitment to sustainability is deepening as the team lays the foundations for a resilient, scalable energy ecosystem as this project plans to scale and replicate. The project vision extends beyond just shuttle operations, growing into a comprehensive energy management strategy that supports the entire infrastructure of the Zion National Park Discovery Center. The team is conceptualizing pioneering grid and off-grid solutions to power an intricate network of facilities and transport services, encompassing a full spectrum of energy stewardship that integrates the latest in technology for generation and storage. In tandem, we are scrutinizing hydrogen fuel cells as a versatile power source for both shuttle propulsion and broader energy requirements at the site.

In this period of informed progression, every infrastructure decision is imbued with the promise of expansion and innovation. The EVZion project is not only transforming the transit system but also forging a resilient, state-of-the-art energy environment destined to lead the charge in sustainable solutions.

This year, the project stands as a beacon of ingenuity and environmental efficiency. The forward-thinking solutions the team is implementing for Zion National Park are designed not only to meet today's needs but also to serve as a sustainable blueprint for the future — expanding what is possible for national parks and similar environments across the nation.

Objectives

The objective of this project is to conduct a small-scale proof-of-concept EV shuttle demonstration that connects the gateway communities and neighboring counties in rural Utah to Zion National Park. The project aims to collect and share usage data with a Department of Energy (DOE) Federally Funded Research and Development Center for further analysis, develop lessons learned and best practices, and conduct outreach with other fleets to assist with technology adoption decisions.

One unique aspect of this project is the requirement that the shuttle be able to pass through the historic narrow Mt. Carmel Tunnel in Zion National Park. This tunnel is open to free-flowing traffic for less than 15 minutes a day due to oversized vehicles, buses, and RVs, making it a significant challenge for any shuttle system.

At the conclusion of the pilot, the project aims to propose positive strategies and smart mobility solutions through the design of an electrified and resilient park touring transportation system. This will involve evaluating the usage data, lessons learned, and best practices developed during the pilot, and using this information to inform the design of a sustainable and efficient transportation system that meets the needs of visitors to the park while minimizing the impact on the natural environment.

Approach

The project team is currently working on building capacity for the developed and built site at Zion Mountain Ranch to ensure the success of the pilot and the effective deployment of the shuttle system. These efforts will help the project achieve its objectives and create positive strategies and smart mobility solutions for a sustainable park touring transportation system.

State funding through the Department of Environmental Quality (DEQ) for workplace charging will support infrastructure for ZMLSD, where EVSE will be installed at Zion Mountain Ranch adjacent to the visitor center. UCC is looking to find a meaningful partnership to use the shuttle as a park employee support vehicle on both sides of the park, possibly serving both ZMLSD and the west side main entrance.

EVZion Project: Integrating Innovation with Sustainability - Milestone Achievements

As the EVZion initiative advances, it is essential to highlight the interwoven nature of the project's achievements and how they contribute to the overarching goal of establishing a resilient, sustainable transit model for Zion National Park and beyond.

- The successful **Leadership Tour** in April 2023 was a watershed moment for the project. The team engaged with over 45 stakeholders, including transportation leaders, educators, and community leaders, to unveil the strategic vision for an expanded transit ecosystem. Nelson\Nygaard Consulting's involvement promises to bolster this vision with their expertise in smart transit solutions.

- The symbolic **Ground Planting** event in August 2023 underscored the project's commitment to sustainability with the birth of the **Zion National Park Discovery Center Site**. Over 250 Utah leaders attended the event, which not only celebrated the construction of this new hub but also introduced two new Lightning eMotors ZEV shuttles – tangible proof of the project's zero-emission pledge.

- The partnership with the **University of Utah** and Dr. Masood Parvania's insights are invaluable as we embed **smart, adaptive technologies into Utah's transit infrastructure**. These advancements will underpin the shuttles' performance, ensuring they thrive amid the park's unique environmental challenges while embracing renewable energy systems for a greener footprint.

  - **Ongoing Oversized Vehicle – Mt Carmel Highway Work Group –** This is an ongoing intensive work group formed by Zion National Park to discuss the in-depth issue surrounding the closure of the park roads to oversized vehicles in two years, beginning with limited tunnel escorts and ending the admittance of oversized vehicles.

The integration of advanced technologies has been a methodical and deliberate process, ensuring each step aligns with the project team's mission to have minimal environmental impact and maximum adaptability. This includes not only the shuttles but also the supporting rural energy grid, poised to conduct, store, and deliver consistent, reliable, and ideally, renewable power.

UCC has been promoting the EVZion project through local, statewide, and national media opportunities, and hosted several statewide press events to promote the electric shuttle in the park and nearby communities**.** A full collection of media pieces is included in more detail in the Key Publications section.

Phase III Shuttle, Deployment, EVSE, and Logistics

In the latest update on the Mobility Outdoors Visitor Experience (MOVE) project, UCC's collaborative efforts in the study and refinement of the National Park EV Development Smart Mobility Concept Plan are progressing, with an emphasis on scaling the logistics of visitor movement within Zion National Park and its vicinity. The MOVE plan is a comprehensive mobility strategy that encompasses the entire park ecosystem, including visitor centers, transit operations, transportation hubs, and the gateway communities that serve both sides of the park, as well as adjacent urban centers.

A notable aspect of the project's evolution is its expanded scope, now aiming to cater to the entire transportation network associated with Zion National Park. This includes the significant workforce that supports park operations and tourism, as well as initiatives to alleviate congestion throughout the park's services and facilities.

A key challenge ahead lies in the deployment of advanced electric and fuel cell transit vehicles, a move that promises to redefine the future of transportation within the park while upholding the park's commitment to providing a premier visitor experience. The execution of this initiative is critical as it pertains to Zion National Park, the nation's third most visited national park, where maintaining the integrity of the visitor experience is as important as it moves towards further adoption of sustainable transit solutions.

Results

UCC continued to meet with key Zion National Park transportation leadership to establish logistical routing, EVSE placement planning, and overall deployment of the electric shuttles. The state DEQ has approved the EVSE and has helped fund the ZMLSD by providing funding for workplace charging.

UCC has been working with the East Zion Initiative to explore options for charging, energy efficiency, energy storage, and utility work. UCC joined the ZRC team and supports the board and the larger collaborative efforts to ensure coordination and technical support. The ZRC sponsors several studies, plans, projects, and other strategies to improve the quality of life for area residents and visitors to Zion Canyon.

UCC is playing a critical role in the Zion National Park community, not only with the deployment of the EVZion shuttle but also in expanding working partnerships and participating in visitor use planning and workforce transportation. The shuttle system is being considered as a solution to remote rural transportation needs and could potentially transport tribal interpreters and other community members from Pipe Spring and rural areas to the East Zion Visitor Center as part of the MOVE workforce initiative. UCC is dedicated to ensuring that all visitors, employees, and community members have access to transportation options that are efficient, sustainable, and inclusive.

The EVZion shuttle service, initially celebrated for transporting key community figures and supporting local events such as the Zion Forever Founders Gathering and Utah Clean Cities tours, now confronts new challenges. The region grapples with a severe shortage of employees and trained transit drivers, impacting the operation of existing shuttle and bus systems within Zion National Park. This shortage hinders UCC's ability to gather fresh data with the two new vehicles awaiting data logger installation and driver training from Lightning eMotors.

In response, a strategic plan is in development to deploy the shuttle resourcefully, leveraging partnerships with Southern Utah University (SUU). The plan involves utilizing the shuttle to transport graduate students and visiting professionals, mitigating the current issues caused by inadequate parking and the necessity of carpooling with multiple vehicles, which exacerbates congestion.

A potential resolution under consideration is for the ZMLSD, the shuttle's new proprietor, to employ two SUU professors as insured drivers. With project funds covering insurance costs and providing a stipend, this would not only alleviate transit challenges but also ensure the shuttle's continued contribution to the pilots continued date gathering and further provide a real-world duty cycle with date logging inputs for heating, air conditioning, weight, driving conditions and overall performance.

Lightning eMotors - the New Shuttles

One significant challenge faced by EVZion was the historic Mt. Carmel Tunnel, a marvel of engineering from 1930 that couldn not accommodate oversized vehicles in two-way traffic flow. This problem was central to the project's mission, and the park has made it clear that oversized vehicles will no longer be allowed after 2026.

Lightning eMotors has made a substantial contribution to sustainable transportation within Zion National Park by deploying two customized Lightning ZEV3™ Class 3 passenger vans as part of the Utah Clean Cities East Zion pilot shuttle program. These electric shuttles, introduced on August 22, 2023, support the initiative to alleviate traffic congestion and safety concerns, particularly addressing the historic Mt. Carmel Tunnel's limitations with oversized vehicles. Tailored to the tunnel's dimensions, these shuttles come equipped with rear-facing cameras and foldable side mirrors—innovations by Volition Components—that enhance their maneuverability and efficiency within the park's infrastructure. The deployment signifies a step towards the broader implementation of zero-emission vehicles in natural settings, contributing to the conservation efforts and improving the visitor experience at Zion National Park.

Data Gathering Phase Three

NREL leads data analysis for the EVZion project under a DOE award, with UCC coordinating data gathering and routing analysis. This partnership focuses on optimizing infrastructure, vehicle deployment, and the integration of innovative technologies to enhance shuttle operations within Zion National Park. The EVZion shuttle project is in its pivotal data-logging phase, a year three milestone, which is vital due to the absence of a reliable satellite signal in Zion National Park. The importance of an intrinsic data collection system within the shuttles has been underscored.

In parallel, Lightning eMotors is gathering vehicle-specific data. The intent is to scrutinize and compare these findings with the OEM data, ensuring a comprehensive analysis of the shuttle system’s performance. While the installation of new data loggers is on the horizon, reliance on OEM data remains the interim solution for ongoing data collection efforts.

This update dovetails with the 2022 report highlighting the collaborative data analysis spearheaded by NREL, with the support of a DOE award. UCC's coordination with NREL is pivotal, focusing on optimizing infrastructure integration, the electric vehicle rollout, and the implementation of innovative mechanical and electrical systems.

Data collection spans the maintenance and performance of the electric vehicle fleet, the efficiency of the energy infrastructure, the impact of networked systems, and driver performance metrics. NREL, UCC, and Lightning eMotors' joint endeavor aims to create a data-informed framework that will inform the current project and potentially serve as a template for future sustainable transit initiatives.

Conclusions

The EVZion project team and its partners are working to assess transportation needs and opportunities for Zion National Park and the surrounding gateway communities. This includes evaluating options for workforce transportation, tourism, congestion mitigation, and the use of electric and fuel cell transit vehicles. The project is focused on maintaining the visitor experience while also promoting resiliency efforts for the natural and built environments and addressing serious congestion issues and poor air quality.

The EVZion project, through its collection of milestones, exemplifies a high blend of innovative collaboration engineering and environmental stewardship. With the upcoming Zion National Park Discovery Center at its heart, the EVZion pilot is set to redefine the future of sustainable transportation and energy management within our nation's treasured parks.

Key Publications

2023 Videos highlighting EVZion
EV Zion Project Highlights Video
Utah Clean Cities 2022-2023
Utah Clean Cities Project Stories
2023 News Media
Zion National Park's shuttle buses are ditching the propane and going electric
Lightning eMotors Electric Vans Power Utah Clean Cities Shuttle Program
2023 Utah Clean Cities Newsletters highlighting EVZion Project Activities
UCC EVZion Shuttle Project Site Visit 2023- May 2023 Newsletter Pages 1 and 2
UCC EVZion Shuttle Project Site Visit YouTube Video Released- June 2023 Newsletter page 5
August 2023 Mid-Month Newsletter- page 5 and 6

Acknowledgements

The Utah Clean Cities team would like to recognize the efforts of Daniel Nardozzi, the project's National Energy Technology Laboratory Project Manager, Utah Clean Cities Board of Trustees, and our EVZion Partners.

I.11 Electrifying Terminal Trucks in Un-Incentivized Markets (Metropolitan Energy Center)

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Start Date: October 1, 2019 End Date: December 31, 2022
Project Funding: $1,781,776 DOE share: $780,000 Non-DOE share: $1,001,776

Project Introduction

Metropolitan Energy Center (MEC) is a nonprofit organization with a 40-year history of transforming energy use in the building and transportation sectors in the Kansas City region and beyond. MEC houses both the Kansas City Regional and Central Kansas Clean Cities Coalitions. Through the coalitions, MEC has brought together public and private stakeholders to promote clean fuels, fuel efficiency, and new transportation technology. MEC has 25 years of experience working with alternative fuel vehicles of all types. This project, Electrifying Terminal Trucks in Un-Incentivized Markets, simultaneously fulfills aspects of MEC's energy transformation strategy and meets the objective to accelerate the deployment of commercial electric vehicles and supporting infrastructure.

Despite being a commercially proven concept, electric vehicles are still demonstrating financial and technical viability in a variety of markets, including manufacturing and distribution settings. The electrification narrative often cites total cost of ownership (TCO) as lower with an electric vehicle due to lower maintenance and fueling costs, but the long-term vision of TCO is not a convincing argument for fleets with limited cash flow. This project demonstrates all-electric terminal tractors manufactured specifically for that duty cycle by Orange EV. Through observation, interviews, and quantitative data capture, MEC will validate the speed with which fleets earn back the capital costs of replacing diesel terminal tractors with electric models, generate case studies that can be used throughout industrial markets in Clean Cities territories, and put four Orange EV T-Series pure electric terminal trucks into permanent service within the region.

Objectives

The objectives of this project are to demonstrate the feasibility of electrification for freight yard and terminal tractor fleets through pilot projects with three fleets and to generate outreach documents that can be used regionally and nationally to promote electrification in other terminal fleets. Project partner Penn State University will analyze telematics and charging data, supported by fleet interviews and operational analysis. Ultimately, MEC will create a deployment guide based on the real-world data and experiences of our pilot fleets in Chicago and Kansas City, so fleet operators across the country can make the move to clean, efficient freight handling.

The technology put into service by the pilot fleets is manufactured by Orange EV. Based in the Kansas City metropolitan area, in Riverside, MO, Orange EV designs and manufacturers all-electric yard trucks in the heartland. They are also the first American company to commercially build, deploy, and service 100% electric Class 8 trucks in container handling operations. The pilot fleets are described below:

- Lazer Spot is the leading provider of yard management in North America, working at 400+ sites in the U.S. and Canada for manufacturers and retailers. Lazer Spot, which acquired Firefly Transportation, deployed two trucks in the Chicago metropolitan area. One of their deployments is Orange EV's all new T-Series Tandem terminal truck. First deployed under this project, the customer-driven tandem axel model spreads weight over an additional axel and is designed to legally transport loads up to 81,000 pounds on public roads.

- Johnson County Wastewater Department deployed one truck running trailers for solids at their new wastewater treatment facility located in Leawood, KS. Johnson County is one of fourteen counties in the Kansas City metropolitan area. Figure I.11.1 shows the truck at its deployment location, during an interview for production of an informational video.

Figure I.11.1 Blue Symphony, a Kansas City-based marketing agency, interviews a vehicle operator at Johnson County's wastewater treatment facility.

- Hirschbach Motor Lines, a private long-haul carrier with emphasis on refrigerated and other specialized services, deployed one truck at a client site in Wyandotte County, KS, located in the Kansas City metropolitan area.
- Orange EV manufactured a demonstration truck that is available for use by interested fleets across the U.S. at no cost except for a shipping fee of $500. The truck has been to more than 20 demonstration sites since 2020.

Approach

In addition to telematics and data collection, the project team held quarterly roundtables during the three-year duration of the project, allowing the pilot fleets to share lessons learned and best practices in their unique deployment settings. Feedback collected from the roundtables will inform key message refinement, identify project champions, and provide content for outreach documents and the final project report. These meetings will also develop relationships across the region, with the goal of demonstrating the feasibility of battery-powered terminal trucks.

Year two of the project was focused on community outreach. Pilot fleets worked with MEC and Orange EV to host at least one community workshop. Presenters shared the benefits of electrification and other alternative fuels in freight applications, and the pilot fleets revealed their experiences and best practices with fleet electrification. The team also generated an informational video under the production of local contractor Blue

Symphony, which shot footage and conducted interviews at each deployment location. Successful workshops with follow-up surveys and meetings will generate new strategic deployment opportunities.

In year three of the project, MEC worked with Orange EV and the pilot fleets to present the project at a national conference. Analysis of all project data is also underway, with a research report intended to provide a reliable basis for replication, as well as resources that will allow more companies to choose electric terminal trucks in the future. A successful conference presentation should also generate new strategic deployment opportunities and apply a multiplier effect on project outcomes.

Results

In 2020 MEC onboarded the project partners, the pilot fleets deployed four trucks, and Orange EV built and deployed the demonstration vehicle. In 2021 MEC focused on data collection and community outreach, which continued into 2022. In 2023 Penn State University began analysis of qualitative and quantitative data collected from the deployments, roundtables, questionnaires, and interviews.

- During the quarterly roundtables, the pilot fleets discussed several topics. During one meeting, the fleets shared their experiences and best practices operating the vehicles in cold weather.

- MEC distributed quarterly questionnaires to the pilot fleets. The questions focused on the following topics: pre-deployment, charging infrastructure, telematics, and vehicle operation and maintenance.

- In October 2021, MEC hosted a virtual community workshop, *Electrifying Terminal Trucks: Best practices and lessons learned from deployments in the Kansas City region and beyond*. The pilot fleets, Orange EV, the project researcher from Penn State, and Kansas City's electric utility each shared their real-world experiences with zero-emission freight handling in a roundtable format. Its recording is available on our project web page and YouTube channel and has been viewed 62 times.

- Produced in late 2021 by MEC contractor Blue Symphony, DRIVING THE FUTURE with Electric Terminal Trucks is an informational video that has been viewed nearly 400 times. It demonstrates real-world operations of electric terminal tractors in various fleets' unique work settings, while sharing the practical and human benefits of heavy-duty vehicle electrification. The video is available on our project website and at our YouTube channel.

- Orange EV has sold and/or leased 27 trucks thanks to the demonstration vehicle funded through the project.

- In April 2022, MEC staff, Orange EV, Penn State, and pilot fleet participant Lazer Spot participated in a fleet electrification panel at Green Transportation Summit and Expo in Tacoma, WA. The session was titled, Zero-Emission Freight Handling: Making the Case with Electric Yard Trucks, and the moderator was Karl Pepple, West Coast Collaborative Lead, EPA Region 10. He presented on the project to a full room and then opened the floor for questions. Questions were mostly related to infrastructure requirements, vehicle technology, and barriers to implementation. The engagement from the audience, training received via conference sessions, and relationship building throughout the conference made the trip a success.

- As of August 2023, the Orange EV demo truck available through the project was deployed 25 times. Twenty-six trucks were purchased or rented by a demonstrating fleet after their company demo'ed the truck.

Upcoming Activities

With our researcher moving from one university to another in early 2022, the analysis work was delayed by several months. MEC has requested an extension through 2023, during which time the wrap-up work of drafting and delivering reports and fleet resources will conclude.

Conclusions

Data collection continued in 2023 for the project. Analysis will take place in 2023. No conclusions to date; expected in 2024.

Key Publications

Video: Driving the Future with Electric Terminal Trucks.
Webinar video: Electrifying Terminal Trucks: Best practices and lessons learned from deployments in the Kansas City region and beyond

Acknowledgements

Report content and project leadership have been primarily provided by Emily Wolfe, Sr. Program Coordinator and Policy Analyst at Metropolitan Energy Center.

I.12 Electric Vehicle Widescale Analysis for Tomorrow's Transportation Solutions (Energetics)

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Start Date: October 1, 2019 End Date: March 31, 2024
Project Funding: $3,999,370 DOE share: $3,999,370 Non-DOE share: $0

Project Introduction

With the rapid increase in vehicle electrification, there is a need for up-to-date, publicly available national data on the usage of plug-in electric vehicles (PEV) and electric vehicle supply equipment (EVSE), also referred to as charging stations. This data must be analyzed to understand end-user charging and driving patterns, as well as vehicle and infrastructure performance, to inform DOE's research planning. Energetics is working with project partners to collect PEV and EVSE usage data from a wide range of fleet types and charging venues from across the United States. Energetics will analyze the data and make summary results publicly available. All data sets and reported results will anonymize data to protect sensitive information. Partners include ChargePoint, Sawatch Labs, Clean Fuels Ohio, Dallas-Fort Worth Clean Cities, Middle-West Tennessee Clean Fuels Coalition, Kansas City Regional Clean Cities, Drive Clean Colorado, Empire Clean Cities, Columbia-Willamette Clean Cities, Palmetto Clean Fuels Coalition, Virginia Clean Cities, and Clean Cities – Georgia.

Objectives

The objectives of this project are to collect, validate, collate, analyze, summarize, and publicly release real-world use data and datasets from PEVs and EVSE, to inform future research and deployment planning efforts. The team will provide project data to Department of Energy (DOE) National Laboratories for additional analysis on a quarterly basis and will make a dataset publicly available. Personally Identifiable Information (PII) will not be distributed or released to the National Laboratories or the public. The critical success factors for achieving these objectives are:

- Building strong collaborative partnerships with existing PEV and EVSE deployment initiatives; Clean Cities coalitions across the country; ChargePoint, an EVSE network provider; and Sawatch Labs, a telematics analytics company.
- Securing diverse and representative PEV and EVSE data from various vehicle deployments and charging station host sites from across the country.
- Developing robust and secure data management and analytics based on the Energetics team's extensive experience with PEV, EVSE, and other fleet data analyses.
- Using multifaceted dissemination channels to ensure widespread stakeholder access to the datasets, including distribution through Clean Cities coalitions; Project Advisory Committee members from state energy offices, utilities, telematics providers, academia, and vehicle manufacturers; state and local organizations; and industry partners.

The project's nationally scaled anonymized dataset and analysis summaries are expected to be highly valuable for a range of entities, including state and federal organizations, regulatory agencies, vehicle manufacturers, electric utilities, universities, National Academies of Science, and fleet operators. The primary goals of this project are to:

- Provide anonymized PEV and EVSE data that augments existing National Laboratory datasets. This data, formatted to leverage National Laboratory capabilities, will be representative of nationwide PEV and EVSE operation.
- Develop and regularly share high-level data summaries and interactive dashboards that provide stakeholders and the public with a snapshot of current PEV and EVSE operations and trends.
- Apply data analytics to answer the project's key research questions, designed with industry expert panel input, and provide new insights on PEV and EVSE uses that will inform the next generation of policies and investments. Key research questions include, but are not limited to:
    - How are PEVs and EVSE being used today?
    - Is PEV and EVSE use changing over time with higher adoption and technological advancements (e.g., faster charging and longer electric ranges)?
    - What are the barriers or challenges to wider adoption for electrified transportation solutions?

Approach

The usage datasets will encompass PEVs and EVSE charging ports representing a diverse set of vehicle sizes, vehicle types, applications, settings, and operating conditions across the United States. The project will apply proven data collection and analysis methodologies to collect, validate, clean, anonymize, analyze, and summarize data from both existing and new PEV and EVSE deployments using a nationwide network of partners. The EV WATTS dataset will consist of three distinct databases with varying access levels, due to the nature of PII or sensitive information.

1. A raw database (multiple tables with utilization and characteristic information for both vehicles and charging stations) and internally generated data tables used to determine sensitivities, PII, anonymization levels, and global statistics. This database will be restricted to a small number of personnel at Energetics for security purposes.
2. A database filtered to remove PII for parties held under a non-disclosure agreement such as the National Laboratories. These tables will be used to transfer quarterly datasets to DOE and National Laboratories (via the DOE Vehicle Technologies Office's LiveWire platform) and to develop associated summary reports and interactive dashboards published by the project.
3. A database filtered of PII and sensitive information, with categorizations of critical data with less specific detail to provide anonymity. The team will publish this database on LiveWire upon project completion and closeout, for widespread public access and use.

Results

Energetics is conducting ongoing EVSE and PEV data collection, management, and anonymization. The team has implemented quality control techniques on the data and added error flags to data that is suspicious. Non-PII datasets are provided to the National Laboratories quarterly via LiveWire, a DOE data platform that can restrict access to certain recipients. Energetics uploaded an anonymized dataset with data through the end of 2022 to LiveWire for public access.

The EV WATTS Team engaged numerous potential data partners to discuss project participation. At the end of September 2023, EV WATTS had secured data sharing agreements from 68 entities and consent for participation from 278 individuals. The quantity of data from these data partners is approximately 50,000 EVSE charging ports and 1,000 PEVs.

Energetics published an online interactive dashboard summarizing the EVSE data collected in 2021 and continues to update the dashboard quarterly. Figure I.12.1 through Figure I.12.3are screenshots from the dashboard that showcase the content of the EVSE database at the end of June 2023 as well as some analysis and results that come from this large nationwide collection of real-world station operations.

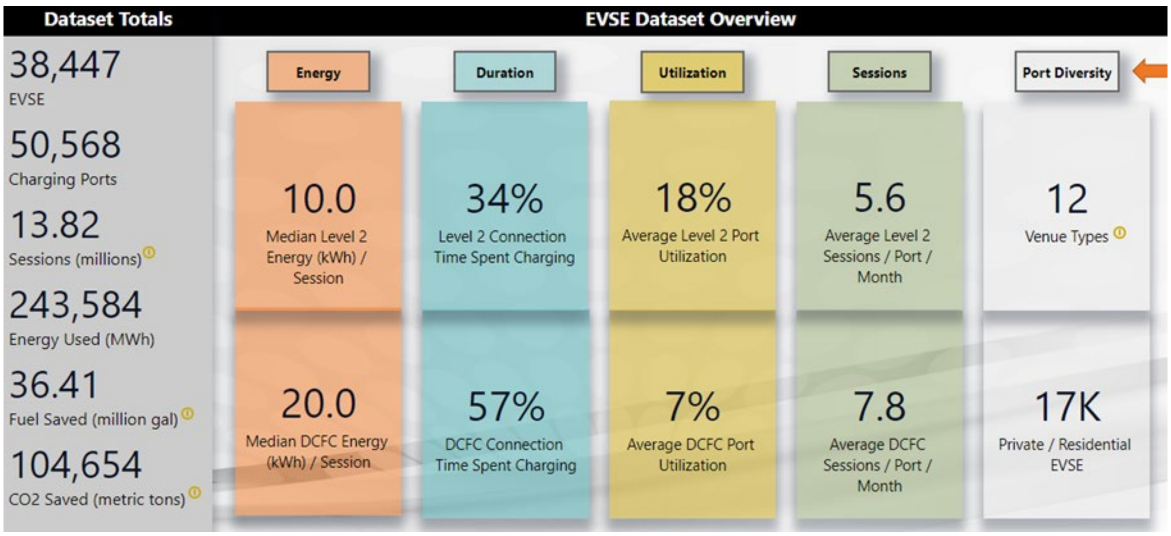

Figure I.12.1 EV WATTS EVSE Database Dashboard – Summary

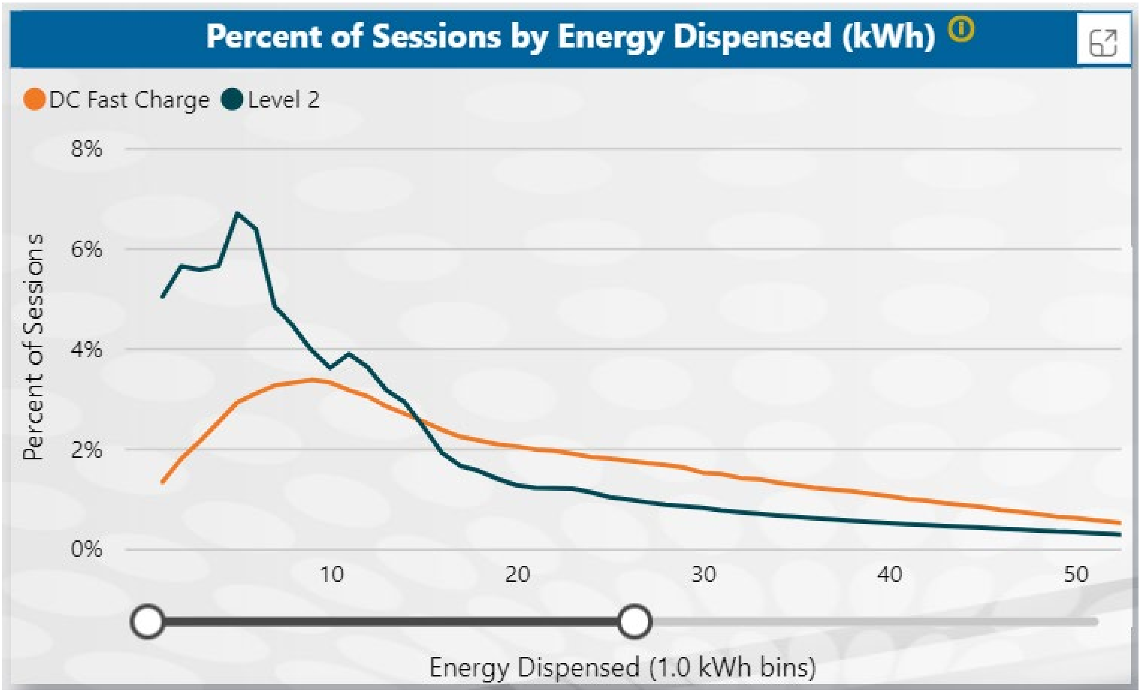

Figure I.12.2 EV WATTS EVSE Database Dashboard – Example Energy Analysis Result

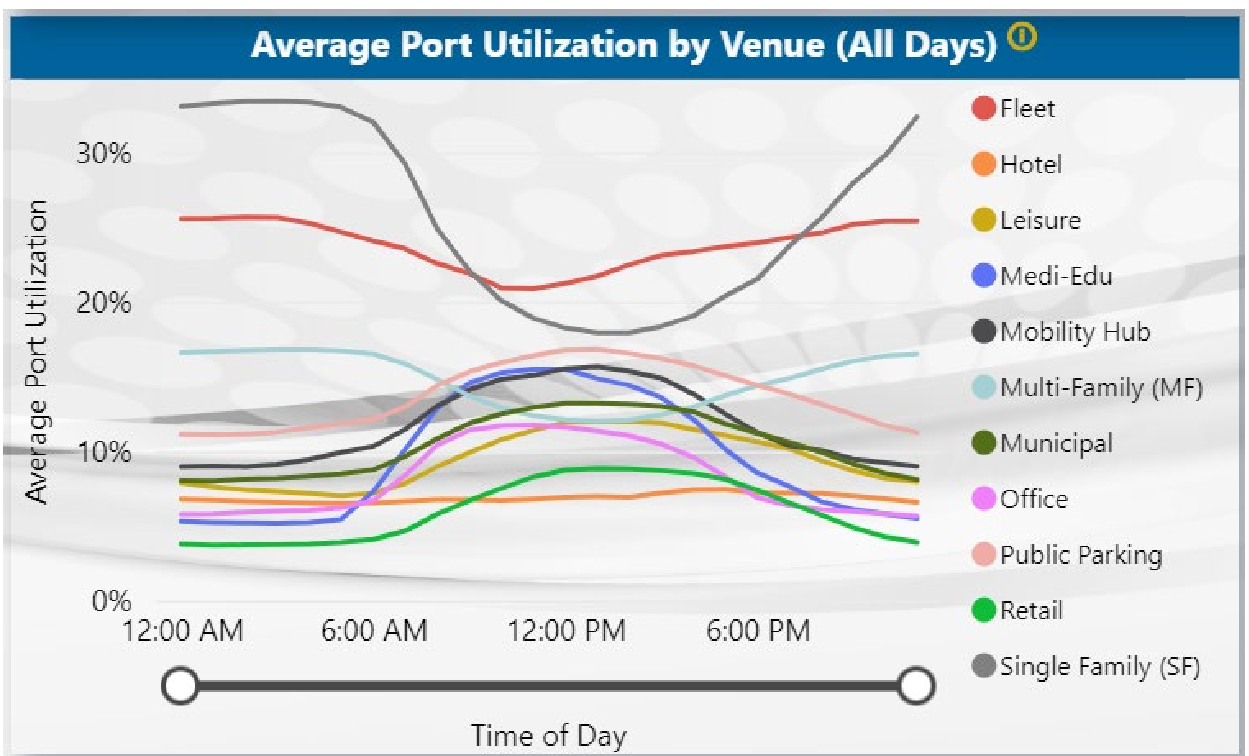

Figure I.12.3 EV WATTS EVSE Database Dashboard – Example Utilization Analysis Result

In 2022, Energetics published another online interactive dashboard summarizing the light-duty PEV data collected that is also updated quarterly. The limited number of medium- and heavy-duty PEVs, along with the significant variation in how those vehicles are used, doesn't easily allow for their inclusion in this dashboard. Figure I.12.4 through Figure I.12.6 are screenshots from the dashboard that showcase the content of the light-duty PEV database at the end of June 2023 as well as some analysis and results.

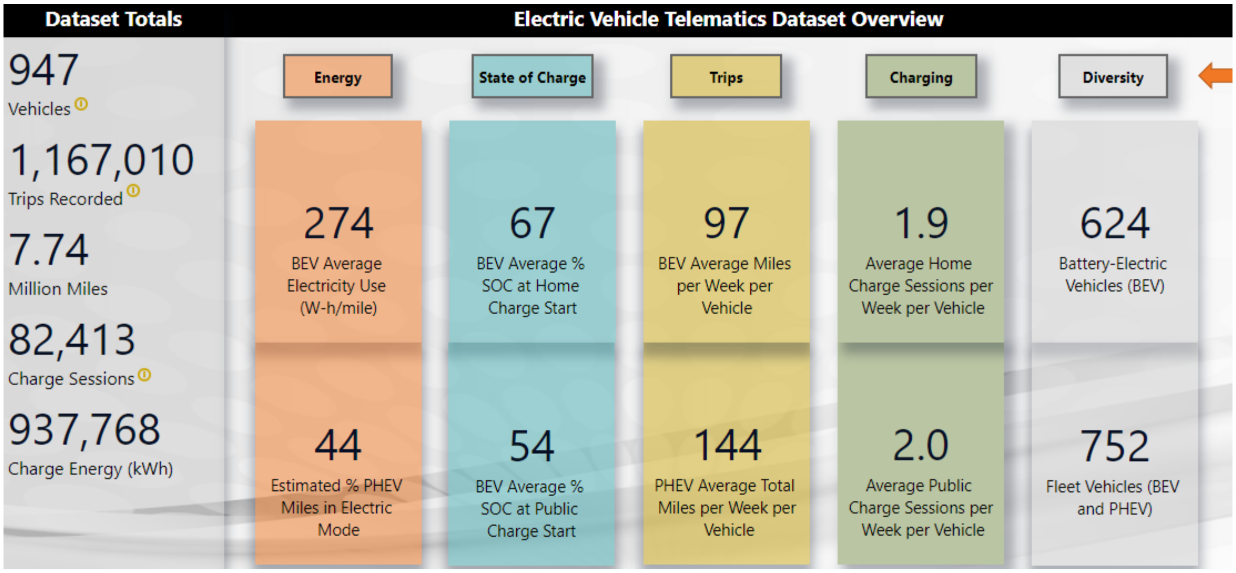

Figure I.12.4 EV WATTS Light-duty PEV Database Dashboard – Summary

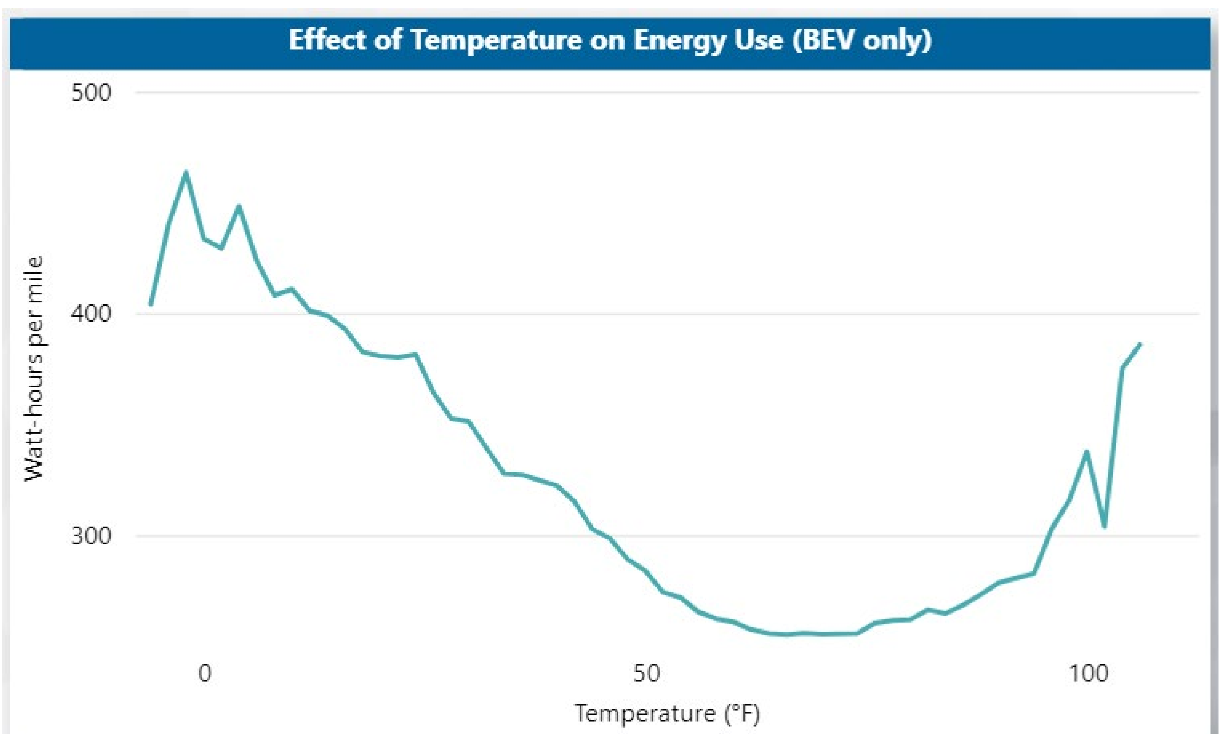

Figure I.12.5 EV WATTS Light-duty PEV Database Dashboard – Example Energy Analysis Result

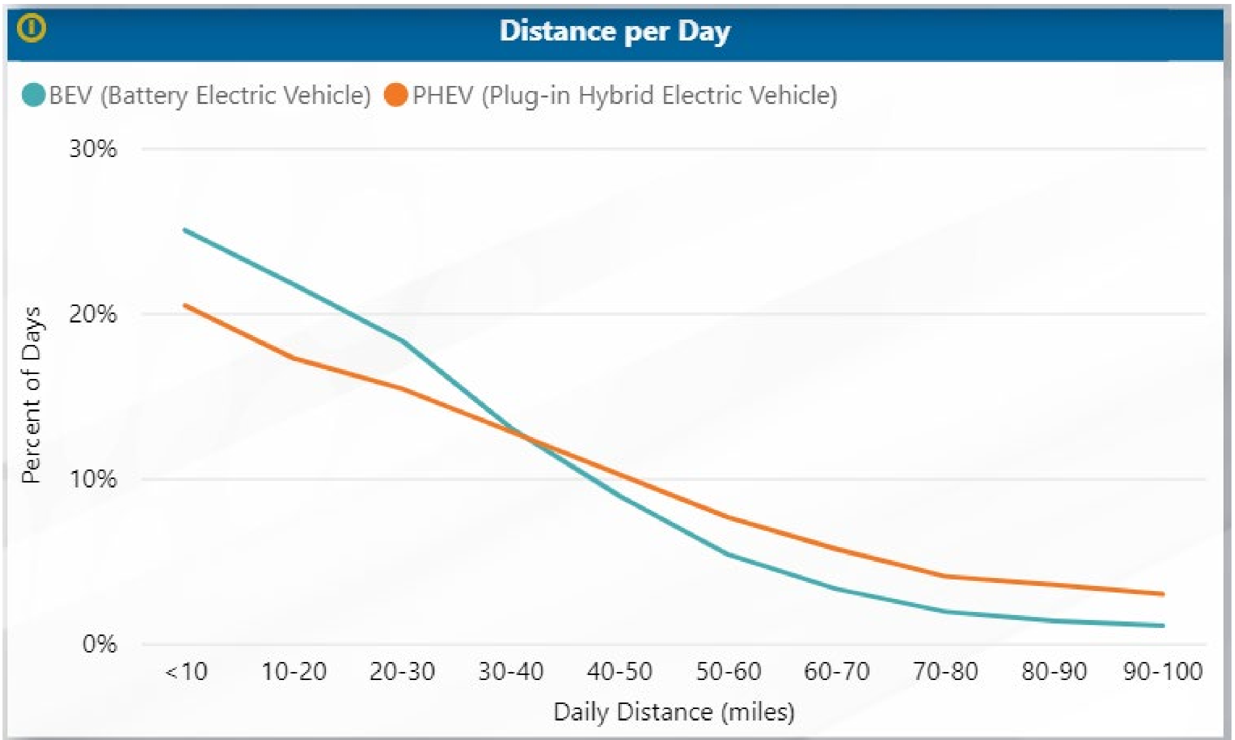

Figure I.12.6 EV WATTS Light-duty PEV Database Dashboard – Example Trip Analysis Result

Conclusions

The collected data and subsequent analyses on that data have revealed valuable insights on how PEVs and EVSE are being used. The EVSE dataset has shown the following interesting results. Further analyses by Energetics and the DOE national laboratories continue to provide additional insights.

- Chargers at single family homes, multi-family homes, and fleets show a distinct u-shaped daily curve because of less daytime charging, whereas most public locations have n-shaped daily curves.
- PEVs are remaining plugged into chargers about three times longer on average than they are drawing power to charge their batteries, although this ratio of plug-in time vs. charging time is much higher for DC fast chargers.
- The median amount of energy dispensed per charging session for DC fast chargers is 20 kilowatt-hours, double that of Level 2 stations which only dispensed 10 kilowatt-hours per session.
- It is rare to have a station occupied more than 50% of the time (due to different driving patterns between day and night as well as week and weekends). Average utilization at public venues between October 2021 and June 2023 was 5-9% for fast chargers and 11-14% for Level 2 chargers.

The PEV dataset has shown the following interesting results.

- PEV energy use while driving averages 255-280 watt-hours per mile when the outside temperature is between 50- and 90-degrees Fahrenheit (F) but is much less efficient in colder or warmer temperatures (averages over 400 watt-hours per mile when it is less than 14 F).

- Plug-in hybrid electric vehicles are driven almost 50% more than battery electric vehicles (144 miles per week on average as compared to 97).
- The average state of charge when battery electric vehicles begin charging is 67%, indicating that the vehicle battery is over sized for most normal driving situations.
- There is almost as much charging occurring away from the home as is done at home.
- While the average travel time and distances increase for longer range battery-electric vehicles, they decrease for longer range plug-in hybrid electric vehicles.

Key Publications

Project materials and an interactive dashboard summarizing the charging station data are available on the project website: www.evwatts.com

Rainey, C. and M. Trybus. 2023. *Optimizing Battery Size for Fleet Battery Electric Vehicles*. Energetics. https://www.energetics.com/user/pages/12.evwatts/white-papers/02.optimizing-battery-size-for-fleet-battery-electric-vehicles/EV-WATTS-White-Paper_Optimizing-Battery-Size_2023.pdf.

Pritchard, E., B. Borlaug, F. Yang, and J. Gonder. 2023. *Evaluating Electric Vehicle Public Charging Utilization in the United States using the EV WATTS Dataset*. National Renewable Energy Laboratory. NREL/CP-5400-85902. https://www.nrel.gov/docs/fy24osti/85902.pdf.

I.13 Medium and Heavy-Duty Electric Vehicle Deployment – Data Collection (CALSTART)

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Start Date: October 1, 2019 End Date: September 30, 2023
Project Funding: $2,166,871 DOE share: $2,166,871 Non-DOE share: $0

Project Introduction

Data on medium- and heavy-duty (MD and HD) electric vehicles (EVs) are lacking and yet very much needed as the trend towards transportation electrification is expected to accelerate. This project directly addresses this problem by collecting, consolidating, organizing, and making available to DOE national laboratory researchers a large set of data from a wide range of electric MD and HD vehicles operating under different conditions.

The primary focus is data collection and analysis for electric MD and HD vehicles (transit buses, school buses, trucks, and off-road equipment). This project is an effort to leverage any recently collected data while strategically planning for and collecting new data from upcoming EV deployment projects across the nation. The data and the extensive research that will be facilitated by consolidating it will help inform the industry, legislators/regulators, researchers, planners, and end-users about future deployments, energy demands, and user trends. There are many potential benefits of having such a comprehensive data source. The impacts the data and the summary analysis could have for the industry are wide-ranging and will likely prove valuable for years to come. CALSTART will work in partnership with the University of California, Riverside, Clean Cities Coalitions, TetraTech, ViriCiti and GeoTab.

Objectives

The objective of this project is to collect, validate, analyze, and provide summary analysis of real-world use data and datasets from electric MD and HD vehicles and electric vehicle charging infrastructure. The use data and datasets will encompass approximately 200 diverse vehicle sizes, types, settings, and operating conditions. All datasets will be used to create knowledge products to share learnings on MD and HD EV deployments across the industry. Project data will be provided to the Department of Energy and will be anonymized and published on the Livewire data platform for public accessibility.

Approach

This project will be conducted in three phases:

Phase 1: Establish the Framework of Data Collection - Establish the data collection framework, including confirming the details of the types of data, storage, and transfer protocols. Confirm the number and type of vehicles and associated data, obtaining any remaining agreements on data from individual project partners from the three dataset categories. Set up the hardware, software, and any technical connectivity needed to effectively collect, store, and analyze project data.

Phase 2: Implement Data Collection - Implement the data collection processes; perform quality control of data collected; and compile, store, and validate the data.

Phase 3: Data Analysis, Reporting and Sharing - Complete the data collection, perform analysis, and provide summary results, making them publicly available. Complete the final report and provide the compiled raw dataset collected to a national laboratory to be determined.

The data types that will be collected through the course of this work will include Vehicle Data and Charger Data.

Vehicle Performance Data

Vehicle data will be collected using on-board data loggers and established data collection protocols based on the extensive experience of the project team. Different types of data loggers may be used depending on the project source. Previously acquired and new data loggers alike will be available for use in this project. The data loggers read vehicle performance data directly from the vehicle's Controller Area Network (CAN) and either store it locally until it can be retrieved or send it over cellular or Wi-Fi networks to a remote, secure server. This allows the data to be checked throughout the data collection process to ensure the data loggers are operating properly. In addition, the data loggers can record Global Positioning System (GPS) data, including the vehicle's location (latitude and longitude, from which speed and road grade can be derived) and altitude. Using the precise location data, weather data will be appended to the vehicle dataset to include the ambient temperature to understand the impact on vehicle performance. For some projects, no additional hardware will be required if the vehicle manufacturer includes data logging equipment as a standard feature. In these cases, a software interface will allow raw data to be transmitted from the manufacturer to the project team's servers for storage and analysis. This transfer may be automated or manual at regular intervals. Every effort will be made to seek participation from the manufacturers to ensure that data is successfully and accurately captured from their on-board systems. Data collection test plans and protocols will be standardized, as much as possible, to maximize uniformity across the projects.

Regardless of the specific device collecting the data, the principal data generated by this project is EV performance data. This includes a wide variety of parameters describing the operation of the vehicle. For example, parameters like distance traveled, vehicle efficiency, total energy consumed, etc. will all be collected from each vehicle included. This data will be collected in addition to vehicle description data such as make, model, year, and battery capacity. Data will be collected over varying periods, depending on the specific project and vehicle availability. The project team will verify, clean, anonymize, and analyze the data using clearly defined steps and uniform processes across all vehicles. CALSTART will collaborate with UCR to inform the definitions of parameters and format of the raw data, ensuring alignment with existing system requirements, before providing it to the designated DOE national laboratories. The project team will perform analyses to provide summarized results, including tables, charts, and other visuals.

Charging Data

Where made available by the fleet, the project team will collect data on charging sessions and energy used for each session from the Electric Vehicle Service Equipment (EVSE) using the charging management software provided on most of the equipment. In the cases where a fleet does not have a smart charger, the team will use any available utility sub-meters to track the energy charged. Vehicle data loggers may also provide measurements on charging sessions and energy charged.

Results

The projects identified for data collection are grouped into the following three categories:

- Category A – Recently completed projects with collected datasets that need to be validated and uploaded.
- Category B – Upcoming projects of which the team is aware and from which it plans to collect data.

- Category C – New projects to be identified through outreach by all project partners.

During this fourth year, the project team continued to execute Phase 3 of the project. In this last phase data collection continued with focus shifting on data analysis to understand vehicle performance trends and the diversity of different use cases. The project team collected, cleaned, and uploaded data from 56 new MD and HD EVs. Additionally, the team collected, cleaned, and uploaded charging datasets for 12 HD EVs. Through further recruitment efforts, the team also established several new agreements for Category C projects where data collection would continue to the end of the project to obtain 12 months of usage data. Table I.13.1 through Table I.13.4 show, by vehicle group, the number of vehicles that are confirmed by signed data sharing agreements and notes their data collection status. In support of the project's outreach component, the team has continued collaboration with the Clean Cities Coalition partners to deliver four (4) recorded webinar events.

Table I.13.1 Status of Vehicles within Category A

	Confirmed Vehicles			Pending Vehicles
	Vehicles with Agreements	Completed Vehicles	Active Vehicles	Not Started
HD	25	25	-	-
MD	-	-	-	-
Off Road	-	-	-	-
School	-	-	-	-
Category A Total	25	25	-	-

Table I.13.2 Status of Vehicles within Category B

	Confirmed Vehicles			Pending Vehicles
	Vehicles with Agreements	Completed Vehicles	Active Vehicles	Not Started
HD	93	82	11	0
MD	21	16	0	5
Off Road	14	8	0	6
School	31	17	14	0
Category B Total	159	123	25	11

Table I.13.3 Status of Vehicles within Category C

	Confirmed Vehicles			Pending Vehicles
	Vehicles with Agreements	Completed Vehicles	Active Vehicles	Not Started
HD	12	2	10	0
MD	6	0	6	0
Off Road	29	29	0	0
School	24	0	24	0
Category C Total	71	31	40	0

Table I.13.4 Summary Counts of Vehicles within all Categories

	Confirmed Vehicles			Pending Vehicles
	Vehicles with Agreements	Completed Vehicles	Active Vehicles	Not Started
HD	130	109	21	0
MD	27	16	6	6
Off Road	43	37	0	5
School	55	17	38	0
Total	255	179	65	11

Conclusions

Throughout the past year, the project collected, aggregated, cleaned, analyzed, and published data from MD and HD vehicle deployments across the United States. As of September 30, 2023, in its fourth year of implementation, the project has uploaded a total of 179 vehicle datasets across all MD and HD vehicle categories.

Over the course of the project, there were several logistical challenges partly due to the rebound of the COVID-19 pandemic. Moreover, fleet participation has been the greatest challenge as an executed data sharing agreement did not guarantee data collection. In addition to fleet attrition, some fleets experienced compatibility issues when attempting to install dataloggers provided through our telematic providers, GeoTab and ViriCiti. Several confirmed fleets anticipating the delivery and deployment of EVs ran into delays or other challenges that resulted in the need for them to drop out. The project team often needed to address concerns with data sharing flagged by a fleet's legal department causing recruitment to become a long and tedious process that furthered delays in the data collection process. Recruitment issues were more prevalent when working with commercial fleets versus public fleets. Despite this challenge, the project is still on track to meet the project objective of 200 MD and HD EV datasets uploaded to DOE's Livewire platform before project closeout. In Q2 2023, CALSTART requested and was approved for a 6-month no-cost extension to allow additional time for continued data collection on active vehicles in the data pipeline. This adjusted the project end date from September 30, 2023, to March 31, 2024.

In the planning phase, the team identified four classifications of data that would be collected throughout the project: vehicle, charging, maintenance, and facility data. The team was unable to collect maintenance data from fleets due to limited accessibility and confidentiality concerns. Fleets worked directly with the manufacturers to have repairs addressed since the majority of EVs were still under manufacturer warranty. As such the maintenance data was not accessible to our project team since manufacturers were not willing to share data on warranty repair costs and had no obligation to provide it.

For facility data, such as utility bills or other operational cost data, it was also difficult to collect at the level of granularity required for useful analysis. Many fleets were nonresponsive to simple data requests, and the time and effort required for a fleet to itemize its utility bill would have been an overwhelming task. Our team decided not to continue pursuing facility data to prevent potentially overburdening fleets with requests where it would pose the risk of them dropping out of the project.

Datasets also exhibit a wide array of variations in quality and comprehensiveness due to the diverse nature of data sources – including different vehicle types, manufacturers, and data platforms. While the datasets uploaded to Livewire aim to create a unified national dataset which follows a consistent framework, raw datasets often vary in their level of aggregation, frequency and consistency of metrics reporting, metrics reported, data quality, and units reported. As a result, data processing has usually required an individualized approach for each fleet, leading to longer processing times.

We have also encountered issues with fleets needing dataloggers, with delays occurring during a secondary contractual process that requires fleets to sign a telematics agreement in addition to a general data sharing agreement. Some fleets monitor their vehicles via proprietary dataloggers pre-installed by Original Equipment Manufacturers on vehicles, requiring the involvement of an additional party to authorize sharing data and adding another layer of complexity to the agreement with those fleets. During 2023, the project team provided quarterly updates to a public facing medium and heavy duty (MHD) dashboard that allows users to interact and visualize the collected vehicle data in different analytical formats. MHD EV Data Visualization Dashboard, shown in Figure I.13.1, includes insights on vehicle performance, vehicle attributes, duty cycle characteristics, energy efficiency, and temperature impacts. The dashboard serves as a publicly accessible tool to explore and share insights on the growing volume of data collected through the project with the goal of informing research efforts and decision making on public policies, fleet operations, and industry development.

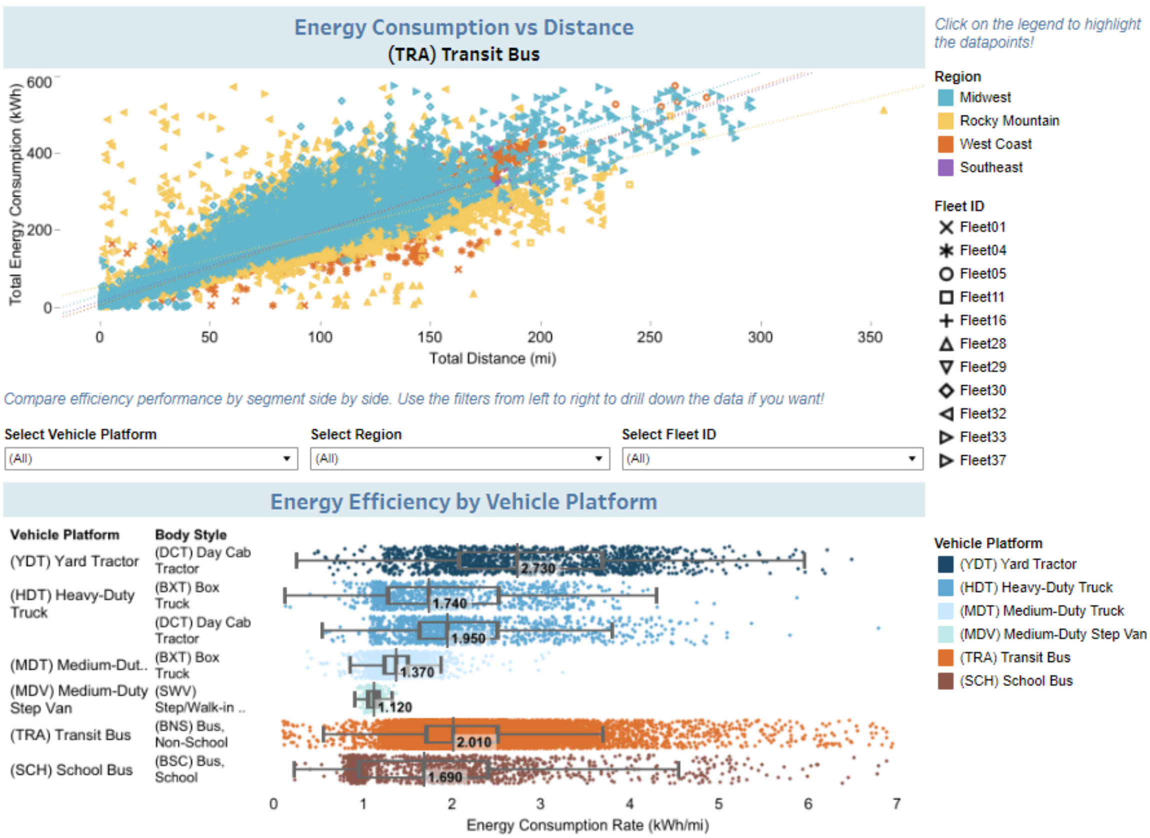

Figure I.13.1 CALSTART MHD EV Data Visualization Dashboard – Energy Efficiency

In addition to the dashboard, the project team delivered ten (10) fleet report cards to participating fleets that completed their twelve (12) months of data collection. The Fleet Report Card is a customized and standalone webpage (HTML file) shared with each participating fleet to present key metrics from the data collection while also providing actionable insights. Figure I.13.2 includes some examples from the fleet report card to show energy efficiency performance of the overall fleet and seasonal impacts.

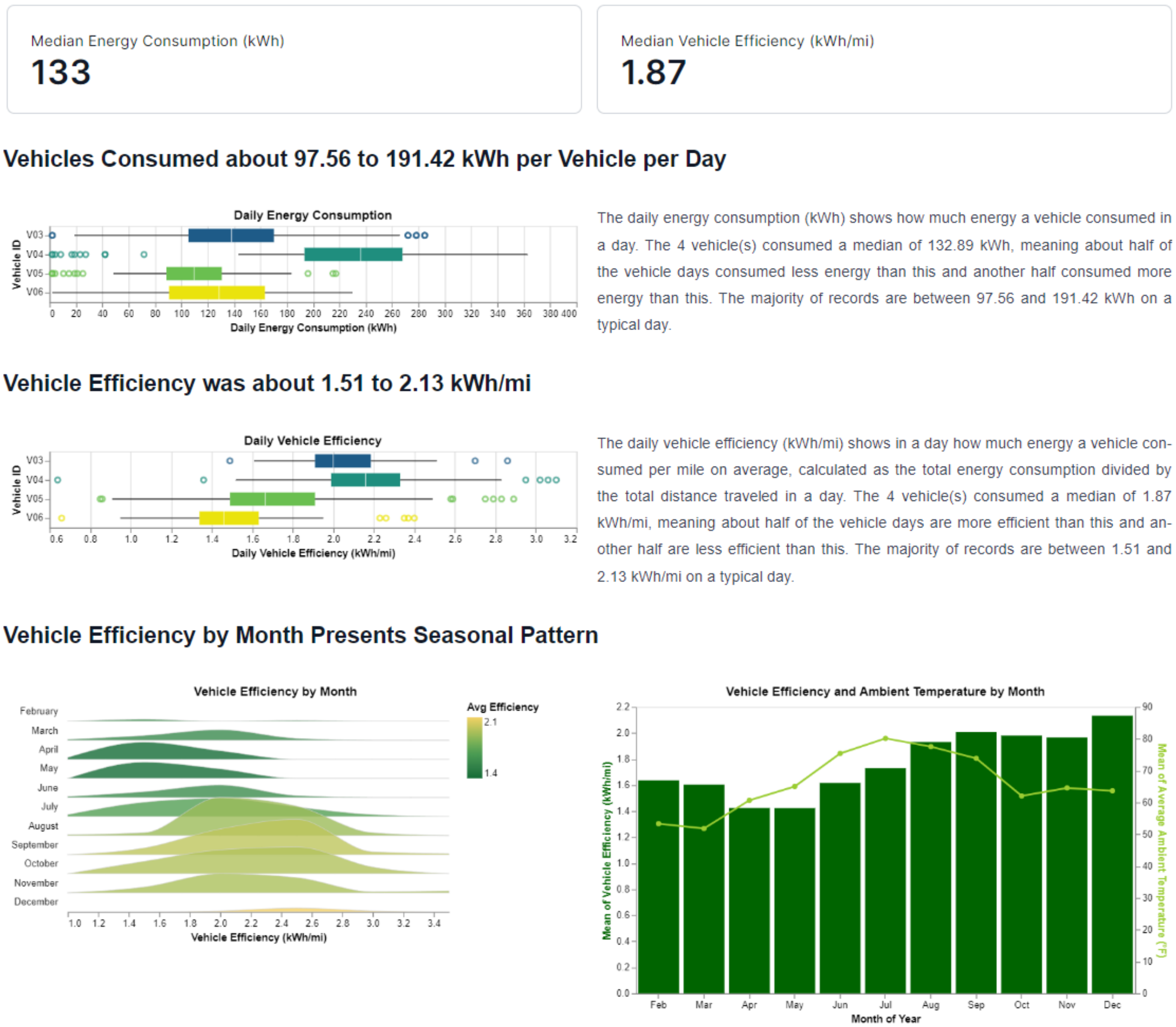

Figure I.13.2 CALSTART Fleet Report Card - Visualization Samples

In June 2023, the project team presented at the 36th Electric Vehicle Symposium and Exposition (EVS36) in Sacramento, California. The presentation highlighted key project findings on understanding the *Real-World Energy Efficiency Analysis and Implications for Medium- and Heavy-Duty EV Deployments Across the United States*. The research provided in-depth analysis on energy cost savings on MD and HD EVs in comparison to their fossil-fueled counterparts.

In September 2023, the project team was invited to submit a revised version of the EVS36 conference paper to the EVS36 special issue of the World Electric Vehicle Journal (WEVJ). The team re-ran all EVS36 paper analyses using the most up-to-date version of the DOE dataset, which included additional vehicles and regions, for the WEVJ submission.

Key findings from the EVS36 and WEVJ analyses include:

1. EVs were found to be 3–6 times more energy efficient than their conventional diesel counterparts, depending on vehicle platform (Table I.13.5).

Table I.13.5 Average and 95% Confidence Interval of Energy Efficiency by Vehicle Type. MPDG and MPDGe Indicate Miles per Diesel Gallon and Miles per Diesel Gallon Equivalent, Respectively.

Vehicle Type	Vehicle Platform	Average EV Energy Efficiency (MPDGe)	Average Baseline Fuel Economy (MPDG)	Energy Efficiency Ratio (EER)
Medium-Duty Truck	Class 4 Step Van	34.18 (±0.22)	9.04	3.8
	Class 6 Truck	28.09 (±0.18)	8.21	3.4
Heavy-Duty Truck	Class 7 Truck	16.89 (±0.35)	4.40	3.8
	Class 8 Truck	20.58 (±0.40)	3.56	5.8
Bus	Type C School Bus	27.16 (±0.73)	7.06	3.8
	35-40 ft Transit Bus	19.07 (±0.08)	3.83	5.0

2. By using EVs instead of diesel vehicles, fleets should experience significant energy cost savings from 2021 to 2035, regardless of vehicle platform, with the greatest savings seen in transit bus and HD truck fleets, especially those with high-mileage duty cycles (Figure I.13.3).

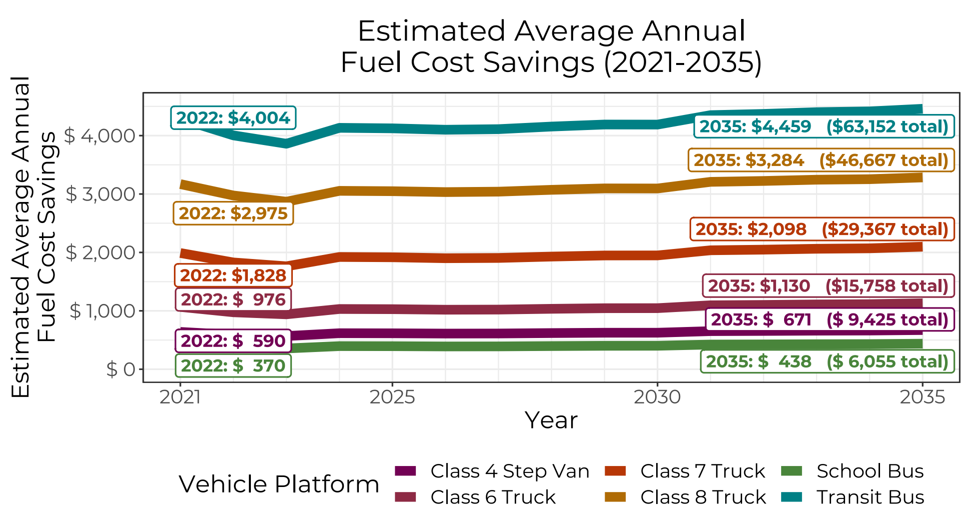

Figure I.13.3 (WEVJ submission) Estimated average annual fuel cost savings by vehicle platform from 2021–2035. Annotations indicate 2022 and 2035 cost savings estimates, as well as cumulative total estimated cost savings by 2035

3. An EV's operational range could be substantially lower than its nominal range in conditions of low temperatures, high congestion, hilly terrain, and local duty cycles. CALSTART developed a machine learning model based on Gradient Boosting algorithm (77.2% in R^2) to predict MHD EV's energy efficiency from 22 real-world factors, and then applied to estimate year-round operational range of any given EV model in any given U.S. city. Figure I.13.4 identifies the top features that are most prominent in predicting energy efficiency so as EV range, including driving speed, congestion, and ambient temperature.

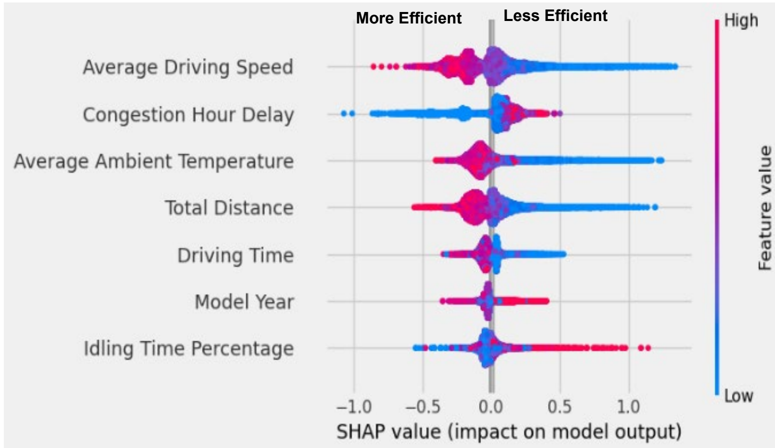

Figure I.13.4 Top Features to Determine EV Efficiency and Range Performance in the Model

By applying the predictive model to multiple heavy-duty vehicle (HDV) operation scenarios, the study demonstrated the use of the model and confirmed the significant impact of colder temperature on vehicle efficiency and range (in Missoula, operational range of transit bus dropped by 30% in winter relative to summer); local hauling (less than 100 miles daily) HD truck fleets may need to deploy trucks with a nominal range nearly double the expected daily range to meet higher energy demand in more extreme duty cycle conditions.

Key Publications

Project Dashboard: Medium- and Heavy-Duty EV Deployment: Data Collection - CALSTART
CALSTART EVS36 Paper: Implications of Real-World Energy Efficiency on Fuel Cost Savings and Operational Range.pdf (June 11-14, 2023)
UCR/CALSTART GTSE Presentation: Real-World Operation and Energy Use of Heavy-Duty Electric Trucks Across Fleets In Southern (August 22, 2023)
DOE M/HD Podcast: Empire Clean Cities, Part 2 (October 17, 2022)
DOE M/HD Webinar: Midwest ZEB Working Group (March 1, 2023)
DOE M/HD Webinar: Drive Clean Colorado (August 30, 2023)
DOE M/HD Webinar: Empire Clean Cities (September 30, 2023)

Acknowledgements

We would like to acknowledge the support from the national laboratories including researchers from Idaho National Laboratory, Argonne National Laboratory, National Renewable Energy Laboratory, and Pacific Northwest National Laboratory, that have been providing advice on the data types. We also would like to acknowledge the close coordination with the EV WATTS project team that was funded in parallel and is led by Energetics.

I.14 Mid-Atlantic Electric School Bus Experience Project (Virginia Clean Cities at James Madison University)

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Start Date: October 1, 2019 End Date: December 31, 2023
Project Funding: $1,668,349 DOE share: $670,000 Non-DOE share: $998,349

Project Introduction

Figure I.14.1 Mid-Atlantic Electric School Bus Experience Project Logo.

The Mid-Atlantic Electric School Bus Experience Project (MEEP) (Figure I.14.1) is working with school bus manufacturers, Clean Cities coalitions and other partners to support existing electric school bus (ESB) deployments and provide ESBs for free short-term demonstrations in selected school fleets in Virginia, Maryland, Washington D.C., Pennsylvania, and New Jersey. ESBs are an exciting tool for school districts to reduce operating costs; improve local air quality; achieve sustainability goals; and protect the health of children.

These demonstrations are a fantastic opportunity for school administrators, mechanics, drivers, faculty, and the public to experience ESBs firsthand without any cost or long-term commitment.

Partners Include: Virginia Clean Cities at James Madison University (lead), Greater Washington Region Clean Cities Coalition, Eastern Pennsylvania Alliance for Clean Transportation, Maryland Clean Cities, New Jersey Clean Cities Coalition, Vermont Energy Investment Corporation (VEIC), National Association for Pupil Transportation, Generation 180, bus manufacturers (Thomas Built, Proterra, and Blue Bird), state air agencies (Virginia Department of Environmental Quality (VA DEQ), Maryland Department of the Environment (MDE), New Jersey Department of Environmental Protection (NJDEP), and regional electric utilities (Dominion Energy, BGE, Pepco, and Exelon).

Objectives

The objectives of MEEP are to provide school districts with experience operating ESBs in their fleets, and to generate detailed, in-use data and information to allow other school districts to make future procurement decisions.

MEEP provides a user level introduction to ESB technology in the region; provides a wide range of stakeholders with needed information about ESBs; allows school districts to gain experience with ESBs from multiple manufacturers; evaluates vehicle performance (including comparison to baseline conventional fuel buses); troubleshoots issues that arise; and provides findings that can be used to intelligently advance the technology.

These elements are critical to advancing ESB technology in the Mid-Atlantic region, which, at the start of this project, had not seen any deployments sufficient to inform decision-making.

Approach

During this reporting period (October 1, 2022, through September 30, 2023), the MEEP project team has worked with school districts and pupil transportation contractors to collect experiences and operational data from ESB deployments and has connected districts and school transportation contractors with information and short-term demonstrations of ESB technology.

The MEEP project team worked with school districts and pupil transportation contractors to support short-term ESB demonstrations in the multi-state project region. In addition to short-term vehicle demonstrations, the project team also worked to support pupil transportation fleets interested in the U.S. Environmental Protection Agency's (EPA's) 2023 Clean School Bus Program Grant and 2023 Clean School Bus Rebate and multiple state-level funding opportunities. This support was provided through hosting multiple webinars, connecting fleets with technology providers and original equipment manufacturers (OEMs), and connecting school districts with peers who already have experience with the technology.

The MEEP project team has been supporting school partners before, during and after the demonstration period, helping to facilitate the process and providing technical assistance, including staff training to support operations and data collection. Participating school partners are also eligible to receive a free Level 2 charging station for charging the bus during the demonstration project, and for use by the school after the project. School partners who have supported the project by providing operational and experience data are also eligible for these chargers. This project is presenting "on the ground" use studies and success stories for local, state, and national deployment of ESB technologies and compiling the lessons we have learned for dissemination. This is critical to providing confidence for future decision-making that fully considers the cleaner ESB option.

Results

In this last year, the MEEP project supported eight short term demonstrations, and focused efforts on collecting operational and experience data from ESB fleets and compiling lessons learned and resources to share with school districts interested in the technology.

Supply chain difficulties that have arisen since the start of the COVID-19 pandemic exacerbated ESB manufacturing and deployment delays. These supply chain issues, in addition to the increased demand for ESBs across the country, have increased delivery timelines. This created delays in data collection and analysis publication. In addition to these delays, many of the school buses that have been deployed long enough to collect sufficient operational data are involved in complex data sharing agreements, such as those involved in fleet subscription services and those with bus infrastructure funders such as Dominion Energy's utility-led programs. As a result, this year the project team pivoted focus to smaller ESB deployments and hand-tracked operational data, data collected by state funding programs, and experiential data from school districts.

Figure I.14.2 School staff and New Jersey Sierra Club members at the "Let's Get Rollin - Electric School Bus Tour Atlantic County" event on June 13 hosted by New Jersey Clean Cities.

Figure I.14.3 On April 22, Greater Washington Region Clean Cities Coalition hosted an Earth Day event which drew more than 100 participants who rode an electric school bus and joined cleanup efforts in the District.

Over the past few years, we have seen increased funding for ESBs from public and private sources. EPA's Clean School Bus Program brought ESBs to the forefront of the pupil transportation industry at a national level. While the funding and demand for ESBs has made it more challenging to secure them for long-term demonstrations, it has provided the project team the ability to uplift and support school districts, especially disadvantaged school districts, in their ESB journeys.

The MEEP project allowed our partners to use the information, contacts, and resources available through the program to connect with and provide one-on-one support to these school districts. Project team members were able to connect with school systems to present actionable information on the EPA programs and facilitate technology budgeting and planning. A barrier that often arises with large funding opportunities is the limited time that applicants are given to submit applications, especially disadvantaged communities that may not have designated grant writing staff. In rural and disadvantaged communities, school district staff often wear multiple hats leaving little time and resources to sort through funding and new technology.

While funding programs, such as the 2022 round of EPA's Clean School Bus Rebate Program, distributed ESB funding quickly, we found some cases where school districts had the false impression that this early-stage technology requires little planning. The 2023 EPA Clean School Bus Grant Program demonstrated this need for planning and highlighted the value of programs such as the Mid-Atlantic Electric School Bus Experience Project. Team members facilitated state and national outreach explaining technology, hosted demonstrations, and collaborated with a wide range of environmental and technology outreach partners (Figure I.14.2 and Figure I.14.3). Simple solutions like key messages and material for visual learners allowed this information to connect with school fleet audiences across the project region.

As 2023 is the final year for the Mid-Atlantic Electric School Bus Experience Project, there has been a large focus on creating and compiling resources based on the lessons learned from this project that will be able to live on after the project's end date. These resources draw on the expertise of the project team, the bus dealers, manufacturers, charging companies, fleet managers, environmental organizations, national labs, federal and state agencies, and electric utilities involved with ESBs.

Project team activities this period included:

- Conducted project bi-weekly calls.

- Supported school districts interested in the 2023 EPA Clean School Bus Grant Program.
- Engaged school bus manufactures and dealers representing ESB OEMs including Blue Bird, International, Thomas Built, Micro Bird, Motiv, Lion Electric, Collins, and Green Power.
- Collected and began analysis of operational and experience data.
- Engaged fleet subscription services companies including Highland Electric Fleets, The Mobility House, and In-Charge.
- Wrote eight blog posts on school bus electrification.
- Held eight short-term demonstrations across the project region (Table I.14.1).
- Hosted five virtual events and workshops (Table I.14.2).
- Held school supply drives on two days in Prince George's County where electric school bus educational material was distributed.

Table I.14.1 Short-Term Demonstrations

MEEP Partner	Date	School Districts/ Location
Virginia Clean Cities	10/27/2022	Fredericksburg, VA
Virginia Clean Cities	3/27/2023	Washington D.C. at a national workshop
Greater Washington Region Clean Cities Coalition	4/21/2023	Baltimore, MD
Greater Washington Region Clean Cities Coalition	4/22/2023	Washington DC
Eastern Pennsylvania Alliance for Clean Transportation	4/24/2023	Luzern County, PA
New Jersey Clean Cities Coalition	6/13/2023	Atlantic County, NJ
New Jersey Clean Cities Coalition	6/21/2023	Hudson County, NJ
Eastern Pennsylvania Alliance for Clean Transportation	8/30/2023	Philadelphia, PA

Table I.14.2 Virtual Events and Workshops

MEEP Partner	Date	Event Name
Greater Washington Region Clean Cities Coalition	12/13/2022	ESB Listening Session
Greater Washington Region Clean Cities Coalition and Virginia Clean Cities	3/30/2023	How to get a Demo/ Loaner School Bus
New Jersey Clean Cities Coalition	4/17/2023	ESB Listening Session Conducted by the New Jersey Chapter of the Sierra Club and the New Jeresy Clean Cities Coalition
Greater Washington Region Clean Cities Coalition and VEIC	4/25/2023	Grant Writing Tips for ESBs
Virginia Clean Cities and New Jersey Clean Cities Coalition	6/5/2023	ESB Webinar: Maximize Savings with EPA Funding and Charge Management
Eastern Pennsylvania Alliance for Clean Transportation	6/26/2023	EPA's Clean School Bus Grant Program- a Delaware Valley Briefing

Conclusions

ESB adoption is up, and federal, state, and utility resource allocations show no sign of slowing down. School districts are excited about this technology and are increasingly receptive to it as they hear positive feedback from their peers. With funding opportunities making ESBs more accessible across the nation, the project team has been able to leverage the project to work with federal agencies, national laboratories, and fleets on education, procurement, and deployment. Through these experiences, we have found that these fleets continue to need education and support, particularly for infrastructure decisions and planning. We have also found that this project has given school districts exposure to the Clean Cities program as a trusted resource to turn to for these resources. Finding these needs ongoing, the project team has been working to develop resources that will support fleets in their electrification journeys beyond the end date of the project in December 2023.

Key Publications

"Looking Back on School Bus Electrification Efforts in 2022." *New Jersey Clean Cities* (blog). December 17, 2022. https://njcleancities.org/blog/id/6.

"2022 Funding Opportunity for Energy Improvements at Public K-12 School Facilities – Bipartisan Infrastructure Law (BIL) – Renew America's Schools." January 23, 2023. *Virginia Clean Cities* (blog). https://vacleancities.org/2022-funding-opportunity-for-energy-improvements-at-public-k-12-school-facilities-bipartisan-infrastructure-law-bil-renew-americas-schools/.

"EPA 2023 Clean School Bus Program Opens." April 24, 2023. *Virginia Clean Cities* (blog). https://vacleancities.org/epa-2023-clean-school-bus-400m/.

"Major Milestone: Over 100 Jouley Electric School Buses in Virginia." July 18, 2023. *Virginia Clean Cities* (blog). https://vacleancities.org/major-milestone-over-100-jouley-electric-school-buses-in-virginia/.

"Electrifying School Buses for a Cleaner Future." 2023. *New Jersey Clean Cities* (blog). July 18, 2023. https://njcleancities.org/blog/id/9.

"2022-2023 Diesel Emissions Reduction Act (DERA) Funding Is Now Open." August 3, 2023. *Virginia Clean Cities* (blog). https://vacleancities.org/2022-2023-diesel-emissions-reduction-act-dera-funding-is-now-open/.

"Virtual Electric School Bus Trainings (Free)." August 18, 2023. *Virginia Clean Cities* (blog). https://vacleancities.org/virtual-electric-school-bus-trainings-free/.

"The 2023 Clean School Bus Program Has $500 Million in Funding Available." September 28, 2023. *Virginia Clean Cities* (blog). https://vacleancities.org/2023-clean-school-bus-program-500-million/.

Acknowledgements

This work is a collaborative effort and progress has been due to the collective effort of Virginia Clean Cities, VEIC, and the Clean Cities coalitions involved with this project: Greater Washington Region Clean Cities Coalition, Eastern Pennsylvania Alliance for Clean Transportation, Maryland Clean Cities, and New Jersey Clean Cities Coalition. We would also like to acknowledge all the manufacturers, dealers, and school districts that have shown interest in this project and have supported these demonstrations. Finally, we would like to acknowledge the support and hard work contributed to the project by Clean Cities Mid-Atlantic Regional Manager Nicole Kirby.

I.15 Decentralized Mobility Ecosystem: Market Solutions for 21st Century Electrified Mobility (Clean Fuels Ohio)

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Start Date: October 1, 2019 End Date: June 30, 2023
Project Funding: $1,341,999 DOE share: $619,999 Non-DOE share: $722,000

Project Introduction

This project demonstrates an operationally and economically successful model for electric vehicle (EV) adoption and charging station deployment by transportation service fleets [taxis, car-sharing fleets, transportation network companies (TNC)] and by major parking providers (universities, airports, hotels, corporate campuses). The Decentralized Mobility Ecosystem hubs deployed in this project will provide solutions to minimize the financial risks of EV usage for drivers (both commercial drivers and the public) while strategically locating mobility hubs to maximize EV utilization across multiple use cases (taxi, TNC, delivery, car-sharing). Clean Fuels Ohio designed this innovative project to demonstrate solutions that address the main barriers to vehicle electrification in the mobility and transportation services sectors. Additionally, the project is designed to create and disseminate a complete "Replication Playbook," geared toward transportation fleet or parking service providers, that includes a fully framed business plan; design and engineering plans; new commercialized software applications and tools for turn-key scaling; marketing tools; and more.

Objectives

This project will create a decentralized and electrified mobility ecosystem, leveraging Columbus Yellow Cab's growing fleet of electric vehicles (EVs) to bring mobility hubs to three quadrants of the Columbus Region. Each of these mobility hubs will offer a small fleet of EVs and associated charging infrastructure, also known as electric vehicle supply equipment (EVSE), including Level 2 and DC Fast Chargers (DCFC), for use by any licensed drivers. In the second year of the project, project partners continued the planning for and deployment of EVs and EVSE at three locations; maintained and refined a mobile EV reservation platform; began marketing EV mobility hubs to relevant user audiences; and began drafting the Replication Playbook draft.

Approach

While many companies have transformed a segment of their business or provided a single novel service, this project offers a new, integrated mobility platform with 21st century transportation services for all use cases, designed for replication by other taxi or transportation service provider fleets nationwide. This project demonstrates how a decentralized mobility platform will leverage the success of a current taxi business to implement increased services and environmental benefits for users, and provide lower per mile operational costs, lower fleet total cost of ownership, and multiple new vehicle use cases to supplement a traditional taxi business – all while complementing other regional transportation service providers. Clean Fuels Ohio is partnering with Columbus Yellow Cab, HNTB Corporation (HNTB), MobiKit, Greenlots, and the Smart Columbus Program to implement this project. Key differentiators and innovative solutions include Fleet Electrification; Decentralized Vehicle Network; Vehicle Fast-Charging Network; Unified, Neutral Platform for All Users; Environmental Sustainability; Economic Sustainability; and Scalable & Replicable.

Results

Clean Fuels Ohio, in conjunction with project partners, made progress on the following milestones in the fourth year of the project:

1. **Two (2) EV Mobility Hubs Deployed:** Deploy EVs and EVSE at the Southside (Columbus Yellow Cab Headquarters) and Central (Short North) mobility hub locations.
2. **Community Engagement & Marketing for EV Mobility Hubs Completed:** Perform marketing, outreach, and education programing to support access and usage of the EV mobility hubs to local community members and organizations and other relevant user audiences.
3. **Replication Playbook Completed and Disseminated:** Columbus Yellow Cab EV Mobility Hub replication playbook finalized and disseminated to wide transportation electrification audience.

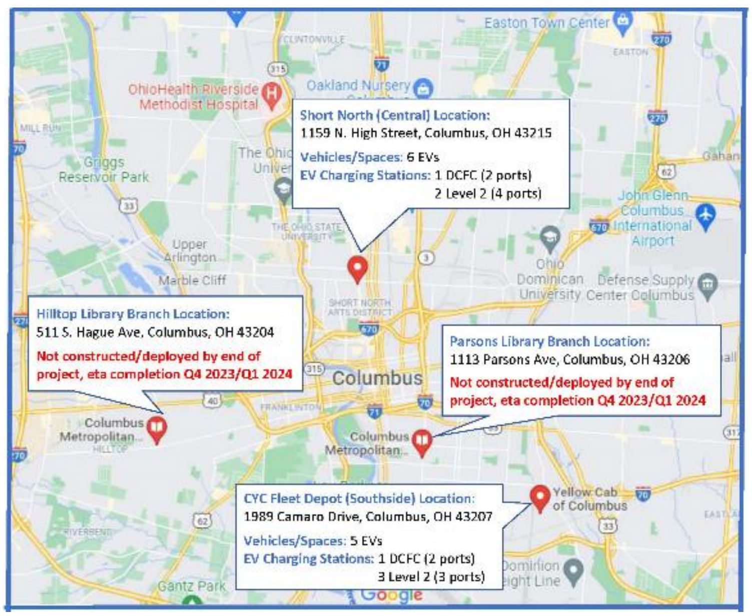

Figure I.15.1 Map and location of two deployed and two undeployed Columbus Yellow Cab EV mobility hubs

Two (2) Mobility Hubs Deployed

Clean Fuels Ohio continued to work with Columbus Yellow Cab to deploy EVs and utilize EVSE at the four project EV charging mobility hub locations (See Figure I.15.1):

<u>Southside Mobility Hub:</u> Columbus Yellow Cab leveraged funding and incentives available through the utility (AEP Ohio) and the Smart Columbus program to install Level II charging and two (2) DCFC charging stations at their fleet depot headquarters location. This location is fully operational and currently providing the main charging facility for the 20 Tesla Model 3 vehicles operational in Columbus Yellow Cab's fleet. The EV charging stations at the Columbus Yellow Cab Headquarters (Southside Mobility Hub) have been operational since 2019. This mobility hub offers publicly available charging via three single-port wall Level 2 48A/240V Tesla connectors (delivering up to 44 miles of range in a 60-minute charge) and non-publicly available but taxicab only reserved charging via two single-port L3 50 kW/480V pedestal charging stations (Efacec QC50 DC Fast Charger) delivering up to 100 miles of range in a 35-minute charge. (See Figure I.15.2).

Figure I.15.2 Southside Columbus Yellow Cab Mobility Hub

Short North (Central) Mobility Hub: Columbus Yellow Cab worked with the City of Columbus, HNTB, EVUnited, and SkyCharge Energy to complete construction and installation of this mobility hub. The EV charging stations in the Short North at the Greenwood Lot (Central Mobility Hub) have been installed and have been in operation since August 2023[8]. This mobility hub offers publicly available charging via two dual-port pedestal Level 2 charging stations (Phihong AW 32A EV AC Charger) delivering up to 25 miles of range in a 60-minute charge and one dual-port pedestal Level 3 150kW charging station (Freewire Technologies Boost Charger 150) delivering up to 100 miles of range in a 10-minute charge for up to six reserved EV parking spaces. (See Figure I.15.3).

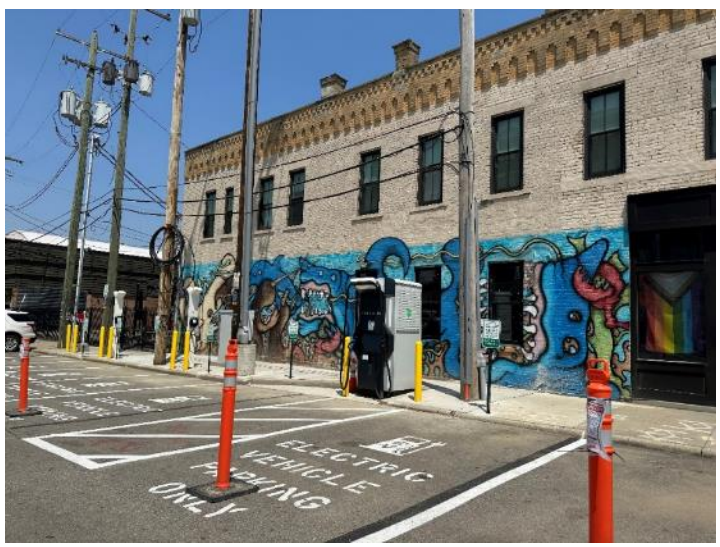

Figure I.15.3 Short North (Central) Columbus Yellow Cab Mobility Hub

Undeployed Westside and South-Central Mobility Hubs: While the site design, engineering plans, EV and EVSE purchases for mobility hubs at all four locations were completed, the project only saw two mobility hub locations at the Columbus Yellow Cab headquarters (Southside location) and the Greenwood Lot in the Short

North (Central location) constructed while the other two mobility hub locations at the Parsons and Hilltop library branches (South Central and Westside locations) were not constructed before the end of the project performance period. The construction of these mobility hub charging stations will not take place until after the performance period of the project by Columbus Yellow Cab and local partners, so they are not counted as a formal accomplishment under DOE EERE funding assistance. The global COVID-19 pandemic impacted these hubs resulting in the delayed arrival of the electric vehicle charging station equipment needed. These delays prevented the completion of the overall decentralized mobility ecosystem, data collection, and analysis of mobility hub networked electric vehicles and charging stations, and further insights from the mobility hub EV reservation app platform shaping the real-time demand of the mobility hubs. Once constructed, both of these mobility hubs are expected to offer publicly available charging via two dual-port Level 2 32A/240V charging stations (Phihong AW 32A EV AC Charger) delivering up to 25 miles in range in a 60-minute charge for up to four reserved EV parking spaces at each library branch mobility hub location. (See Figure I.15.4 and Figure I.15.5).

Figure I.15.4 Westside Columbus Yellow Cab Mobility Hub

Figure I.15.5 South-Central Columbus Yellow Cab Mobility Hub

<u>EV Mobility Hub Reservation App:</u> Columbus Yellow Cab's internal EV reservation platform app, in partnership with Shell Recharge Solutions, is currently available and being used only by its base of 300+ taxi

drivers to reserve and use the fleet's 20 Teslas (See Figure I.15.6). While this app was not launched for public use and demonstration for the local decentralized EV mobility hub network due to the uncompleted construction of the two remaining South-Central and Westside mobility hubs, the public facing capabilities of the app would have served as a mobile reservation platform for reserving and using EVs at the mobility hub locations. The app would have also generated vehicle and charging station insights from each of the deployed mobility hubs and analyzed benefits for showcasing Columbus Yellow Cab's decentralized network of EVs for any use case. Some of these key use cases include EV utilization for transportation network company drivers, on-demand delivery services drivers, car-sharing/-pooling drivers, and general personal use purposes.

Figure I.15.6 Columbus Yellow Cab Internal EV Reservation App for Taxi Drivers

Community Engagement & Marketing for EV Mobility Hubs Completed

Clean Fuels Ohio worked with the City of Columbus Sustainable Columbus team and four community-based organization partners to execute a marketing and community engagement plan for the EV mobility hubs. Clean Fuels Ohio, Columbus Yellow Cab, and Sustainable Columbus are committed to a collaborative approach with community-based organization partners and members of central Ohio local communities. The project team identified and selected community-based partners for each EV mobility hub location to receive grant funding that will support local community-facing outreach, marketing, and education efforts to promote the hubs. The role of the community partners will be to help enable community residents to access the EV mobility hubs through existing individual and community services, and to support the project team with the key activities:

1. Training, marketing, and outreach regarding EV mobility hubs.
2. Promoting, attending, and supporting EV mobility hub events (expos, showcases, trainings).
3. Assisting with community education, awareness, and engagement.

The community partners include IMPACT Community Action (Southside), Zora's House (Short North), Community Development for All People (South Central), and Greater Hilltop Area Shalom Zone (Westside).

Clean Fuels Ohio provided the community partners with knowledge and resources to facilitate engagement within their local communities, to promote broad awareness of the EV mobility hubs, and to enable the local communities to access and utilize them. Resources included information on EV and charging availability, uses, and service models; vehicle and charging station reservation platform/process; trainings for mobility hub users; and community support resources. Clean Fuels Ohio and the community partners leverage relationships to engage with and build/establish clean transportation/mobility access-centered relationships with their community members through outreach, marketing, and education activities. The project team relied on the community-based partners to be trusted sources of broad and general education, and facilitation support. Clean Fuels Ohio finalized and shared a Marketing and Community Engagement Plan with the rest of the project team and the community partners. The plan included goals such as conducting surveys, outreach, marketing, education, training, and events about EV mobility hub availability, access, and utilization.

Replication Playbook Completed and Disseminated

Clean Fuels Ohio and HTNB finalized writing and completed the Columbus Yellow Cab EV Mobility Hub Replication Playbook. The playbook includes sections on existing and future conditions analysis (focusing on transit routes, taxi/TNC routes, routes in charging, etc.); existing resources and feasibility analysis; fleet vehicle telematics and systems analysis; community and stakeholder engagement (focusing on feedback from community areas/zones that were determined to inform and refine the final locations, general validation and support of the mobility hub concept, etc.); design (focusing on design practices, ADA compliance, curbs, grading, site specific design, transformer location, emergency shutoff, equipment, local jurisdiction zoning and building codes, site constraints, etc.); and implementation (focusing on permitting and management best practices). Clean Fuels Ohio disseminated the playbook to relevant transportation electrification stakeholders and user audiences nationwide.

Conclusions

Clean Fuels Ohio, Columbus Yellow Cab, and the rest of the project team based in Columbus, Ohio set out to execute a project that would not only deploy dedicated electric vehicles and associated charging infrastructure, but also pioneer the planning and feasibility for a decentralized mobility hub network that would disrupt the transportation services fleet electrification space. The project team identified existing barriers faced by taxi, transportation service, TNC, car sharing/rental, and mobility-as-a-service providers in the final Replication Playbook.

Key Publications

Decentralized Mobility Ecosystem Website

I.16 Integrated Fuel Cell Electric Powertrain Demonstration (Cummins Inc.)

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Start Date: October 1, 2020 End Date: September 30, 2025
Project Funding: $3,764,624 DOE share: $1,797,984 Non-DOE share: $1,966,640

Project Introduction

Heavy-duty fuel cell electric vehicles are not new to the truck and bus market; however, fuel cell and hydrogen (H_2) technologies have not gained widespread market adoption and have even been supplanted by battery electric technology in some heavy-duty vehicle markets. While the cost of batteries, the most expensive component in battery electric vehicles, continues to go down thanks to increasing order size and growth in passenger electric vehicle sales, fuel cell electric vehicles have not experienced the same growth and resulting fall in prices over the last 10 years. Heavy-duty fuel cell electric vehicles still face technological and market challenges that need to be overcome to advance the adoption and commercialization of H2 technologies. In particular, the integration and packaging of the different components that make up a fuel cell electric powertrain are complex and remain costly. In addition, H_2 fuel prices remain high, the cost of fuel cell stacks and H_2 fuel storage solutions is still high, and there is a need to increase H2 storage energy density. Cummins Electrified Power NA Inc. (Cummins) proposed to design, build, test, and demonstrate a fuel cell electric powertrain for heavy-duty trucks that can help to reduce costs and advance the commercialization of H_2 vehicles. In addition to meeting the goal of the area of interest of the solicitation, the proposed fuel cell powertrain technology offers the following benefits:

1. Vertically integrated
2. Modular and scalable
3. Highly integrated and manufacturable
4. Increased driving range
5. Increased fuel economy
6. Rapid refueling
7. 1:1 replacement of conventional vehicles
8. Total Cost of Ownership (TCO) reduction.

Objectives

The objective of the project is to develop and demonstrate a modular and scalable integrated fuel cell electric powertrain for use in heavy-duty trucks, with the capabilities shown in Table I.16.1. The table has been updated to reflect the approved changes submitted to DOE as part of a contract modification. Changes to the Fueling Time parameter have been updated based on Lessons Learned from other Cummins fuel cell projects and to remove the Component Commonality parameter since the bus portion has been removed from the project. This directional change regarding the fuel cell bus is addressed in the Approach section below.

Table I.16.1 Project Target Metrics

Parameter	Measure
Range (Component Level)	≥ 300 miles (HHDDT* cycle,seal level)
Fuel Economy (Component Level)	Up to 8 miles per kg H_2 (truck)- mileage will be dependent on duty cycles
Fueling Time	≤25 minutes
Vehicle Availability	≥90%
Vehicle Upfront Cost	$600,000 (truck) for 1,000 annual sales
Maintenance Cost	$0.40 per mile
Fuel Cost	$5 - $6 per kg H_2 at high volumes

**Heavy Heavy-Duty Diesel Truck*

Approach

Cummins is the project lead and will provide overall project management, task coordination, and administrative functions for the project. Cummins will also manage all the technical tasks, working with Navistar to design the integrated fuel cell electric powertrain; build, commission and test the prototype fuel cell vehicle; provide service and support during the field demonstration at Werner Enterprises in Los Angeles; assist CALSTART with the data collection and analysis; develop the product development and manufacturing plan; and work with CALSTART and Long Beach Clean Cities on project outreach and the technology commercialization pathway. SoCalGas and South Coast Air Quality Management District will provide cost share to the project, participate in regular project meetings and reviews, and provide feedback to the Project Team on policies and legislation driving the H_2 economy and the commercialization of fuel cell and hydrogen technologies.
A directional change occurred in December 2022 regarding the fuel cell bus portion on the contract. The fleet partner communicated that it was pulling away from the project. Cummins explored options to find an alternative Original Equipment Manufacturer (OEM) partner to not impact the scope of work and schedule but faced challenges in finding one in a quick turnaround, so in March 2023, the project team with the approval of DOE decided to discontinued project activities relating to the bus.

Budget Period 1 - Integrated Fuel Cell Electric Powertrain Design and Assembly; Technology Commercialization: Cummins will design a modular and scalable integrated fuel cell electric powertrain by leveraging existing fuel cell powertrains. The powertrain and its components will be designed to ensure a high level of commonality in components between the truck and bus versions of the powertrain. The truck will be integrated using this design, but integration of the bus is out of scope. Cummins will refine the powertrain layouts and integration processes to make them highly manufacturable. Cummins will construct and commission a prototype fuel cell class 8 truck. In collaboration with CALSTART, Cummins will create and submit part 1 of the Product Development and Manufacturing Plan for the powertrain. It will highlight the overall powertrain cost, the high-volume system component cost, and the quantifying of high-volume production cost estimates, and conduct high-volume total cost of ownership scenario analysis. The remaining subtasks of this plan will continue in Budget Period 2.

Budget Period 2 - Vehicle Testing, Demonstration and Evaluation; Technology Commercialization: Cummins will test the prototype truck at the Cummins West Sacramento, CA facility for performance, safety, durability, and reliability in operation closely simulating the drive cycles typically taken by the end-user fleets. Werner Enterprises, Inc., the end-user fleet, will demonstrate the vehicle for 12 months and operate in real-world conditions covering both hot and cold climates. Werner Enterprises, Inc will thoroughly evaluate the performance of the vehicle and report throughout the demonstration period. Public outreach and data analysis will occur throughout this budget period. Cummins will lay out an actionable technology deployment plan resulting in a Technology Commercialization Roadmap that will identify a viable pathway for commercialization of the Integrated Fuel Cell Electric Powertrain.

The expected outcome of the project is a market-ready fuel cell electric powertrain with operational performance and total cost of ownership that will support near-term, rapid, and substantial penetration of the truck market.

Results

The following has been accomplished during the period of October 1, 2022, through September 30, 2023:

Task 0.0 Project Management and Planning activities continued in Q4 2022. The project schedule and budget require adjustment to recognize the delayed start and shifting of all milestone dates accordingly. In December 2022, Cummins submitted a proposal for modification of Cooperative Agreement DE-EE0009214. The modification included changes to the Scope of Work, fuel cell bus & truck schedules, budget, and a proposal to complete the work on this program through September 30, 2025. In December 2022, Cummins communicated to DOE that the fuel cell bus OEM partner was no longer participating in this project. In March 2023, Cummins communicated to DOE the challenges in finding an alternative bus OEM. In May 2023, Cummins and DOE agreed to redefine the scope of work to the fuel cell truck only and Cummins submitted a new contract modification with changes reflected in budget, scope of work, and schedule. On September 5, 2023, DOE approved and fully executed the proposed modification.

Task 1.1, Integrated Fuel Cell Electric Powertrain Design and Assembly, activities were near completion with subtask 1.1.9 creation of bill of materials and ordering of components underway in late September 2023. In October 2022, the Cummins team engaged with Navistar (fuel cell truck OEM partner) to begin discussions on the powertrain architecture. In Q1 2023, technical discussion was underway on component selection of the hydrogen storage system, fuel cell engine, integration of eAxle in Navistar chassis, and gathering the voice of the customer requirements from the fleet partner. In Q2 2023, the team completed the system concept, fuel cell engine control testing on a test the truck to check system functionality and develop controls interfaces, preliminary vehicle layout, CAN topology, major component selection, and critical system requirements, and procured long lead parts. The team began subtask 1.2.9 (Milestone 2) in September 2023.

Highlights

- Submitted 1st invoice to SoCalGas in November 2022.
- Executed Amendment #1 to Navistar subcontract agreement in December 2022.
- Notified DOE, in December 2022, that the fuel cell bus OEM is no longer participating in the project.
- Mutual decision reached with DOE to remove the fuel cell bus portion from the project in March 2023 leading to an updated modification request (budget & scope of work) in May 2023 and obtained DOE approval in September 2023.
- Completed system concept and planning in May 2023.
- Completed preliminary vehicle layout, CAN topology, major component selection, and critical system requirements in Q2 2023.
- Procured long-lead equipment/materials in June 2023.
- Task 1.1 (Milestone 1) completed in September 2023.
- Began defining scope of work for subcontractor agreements.

- De-contented truck to prepare for vehicle build with eAxle installed in the truck by end of September 2023. See Figure I.16.1.

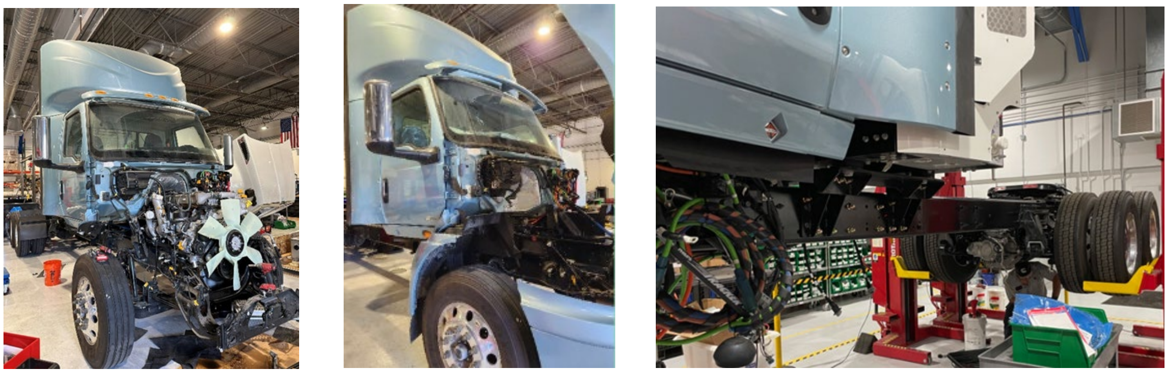


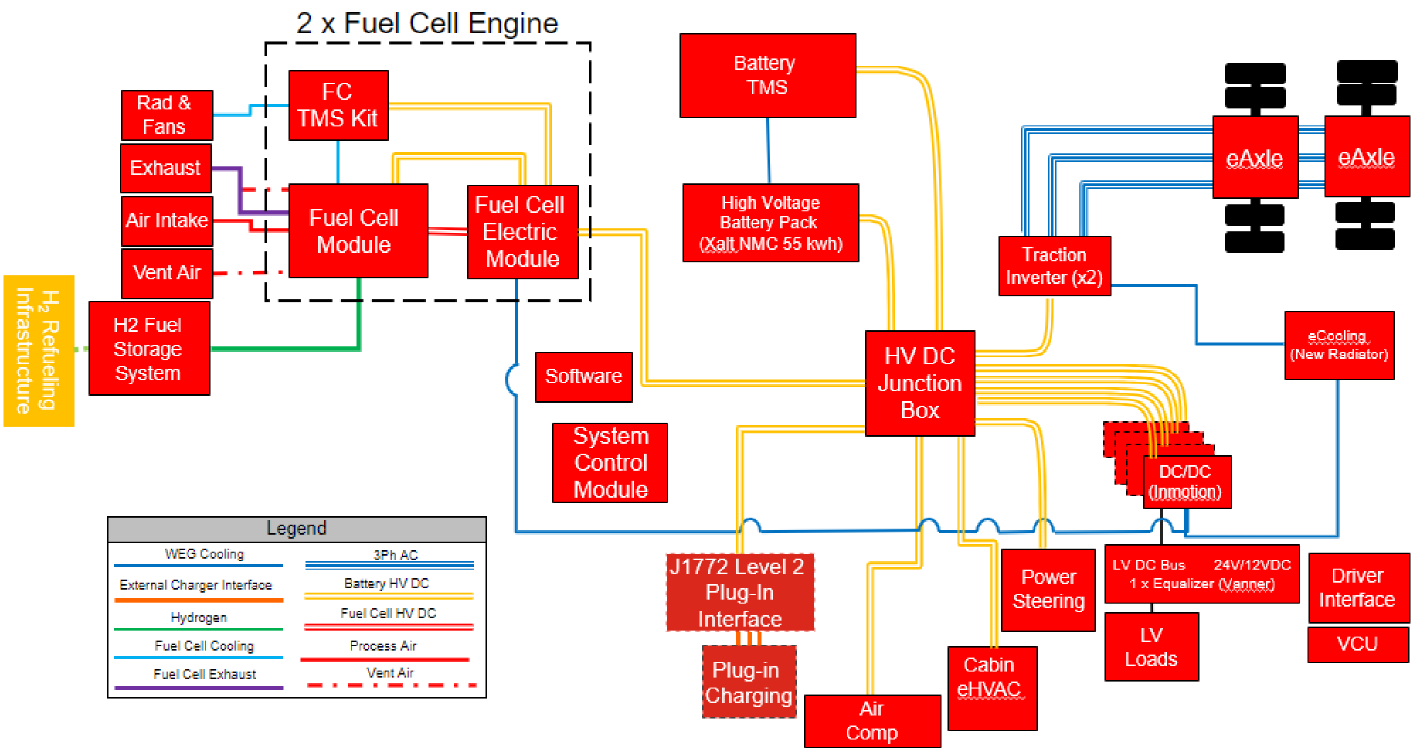
Figure I.16.1 Removal of OEM Parts and eAxle Installation. Source: Cummins Inc

Fuel Cell Truck Material Readiness Status

The team has successfully ordered all the major components required for the project. A majority of these components have been received and are on-site ready for integration. Significant progress has been made regarding acquisition of specialized parts, and parts with custom designs. Some of these parts have already been ordered, while others are in the final stages of order placement. Figure I.16.2 and Figure I.16.3. Electrical Harnesses & Cables: These are the critical parts that are integrated first on the truck, before the major components or brackets. They were prioritized to order in September 2023 soon after the design review. Cummins outsourced the production of electrical harnesses and cables. We are expecting to steadily receive the batches of harnesses in the order of their priority and build sequence.

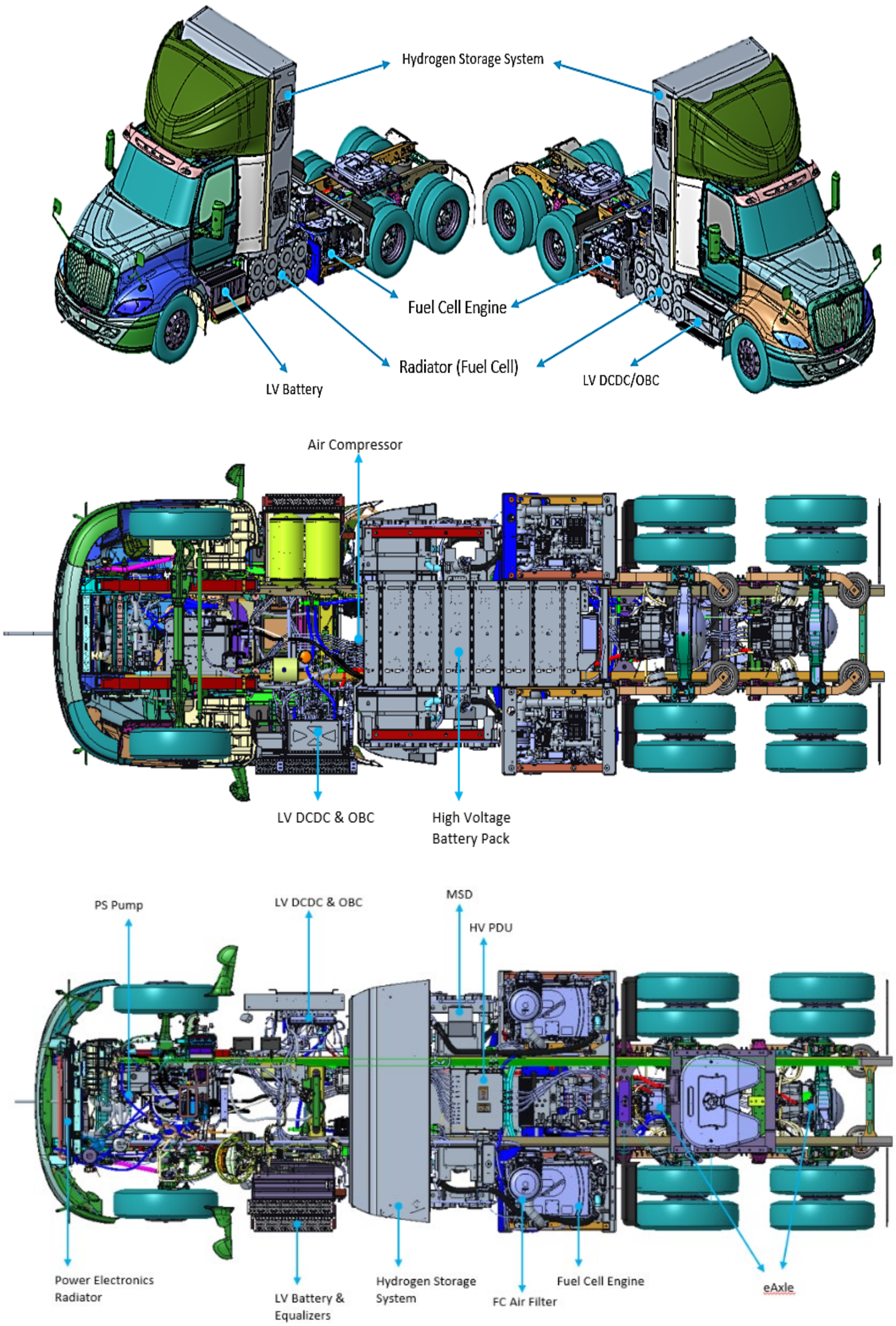
Component Verification and Controls Development

Cummins verified the fuel cell on a designated test truck, and this crucial testing phase allowed us to evaluate fuel cell system functionality and requirements for controls and software development during third quarter of 2023.



Source: Cummins Inc.

Figure I.16.2 Fuel Cell Truck System Architecture



Source: Cummins Inc.

Figure I.16.3 Fuel Cell Truck Computer Aided Design (CAD) Layout

I.17 Field Demonstration of a Near-Zero, Tier 5 Compliant, Natural Gas Hybrid Line-Haul Locomotive (GTI Energy)

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Start Date: October 1, 2020 End Date: December 31, 2024
Project Funding: $5,199,733 DOE share: $2,599,733 Non-DOE share: $2,600,000

Project Introduction

DOE has an objective to increase the utilization of alternative fuels in the railroad industry. Still, it is greatly hampered by a lack of engine technology development from traditional locomotive manufacturers that have historically emphasized incremental change. Prior attempts to demonstrate alternative fuels in rail service from the original equipment manufacturers failed to gain industry acceptance because they achieved only Environmental Protection Agency (EPA) Tier 3 emissions and had relatively low natural gas substitution rates that did not substantially reduce operating expenses. In this project, GTI Energy, in collaboration with OptiFuel Systems, LLC and other partners, is conducting a field demonstration of a 4,300 hp, Tier 5-compliant, Hybrid Line-Haul Locomotive that can operate on compressed or renewable natural gas (CNG/RNG) with near-zero emissions. See Figure I.17.1 for a rendering of the locomotive.

Figure I.17.1 3D rendering of the SD90 locomotive and an independently-funded CNG/RNG tender.

Table I.17.1 shows a comparison of current locomotive emissions standards and the goals of this project. Of the 39,000 total locomotives operating for Class I, II, and III railroads in the U.S., only 3,000 meet Tier 3 emissions standards, and less than 1,000 meet Tier 4. Class I railroads do not support a proposed Tier 5 emission rail standard because there is no reliable locomotive propulsion system that reduces both emissions and operating expenses. This program will integrate a suite of commercially available engine products to create a viable, safe, and reliable CNG hybrid system to power 4,300 hp locomotives with near-zero emissions, exceeding Tier 5 requirements while reducing fuel costs and having a nominal maintenance impact.

Table I.17.1 Locomotive Emissions Requirements and Project Targets

Locomotive Equipment	Fuel Type	NOx (g/bhp-hr)	PM (g/bhp-hr)
U.S. Class I Line-Haul Fleet	100% Diesel	8.5	0.21
Tier 4 Standard	100% Diesel	1.30	0.03
CARB Proposed Tier 5	TBD	0.20	<0.01
OptiFuel (83% RNG), Near-Zero, 4,300 hp	CNG/Diesel Hybrid	0.05	<0.01

Currently, railroads are operating inefficient legacy diesel locomotives with emissions substantially higher than proposed Tier 5 requirements, which are costly to maintain. Reducing criteria pollutants is of critical importance because railyards tend to be in areas where underserved populations have some of the poorest air quality. The project team proposed a multi-engine approach that will increase fuel efficiency by 20% and, with the use of RNG, will reduce greenhouse gas (GHG) emissions by 40%. The use of proven, commercially available equipment (i.e., engines, CNG storage, CNG refueling) and domestic CNG and RNG has both emissions and cost advantages for the railroad industry.

Objectives

The project will develop and demonstrate a near-zero, Tier 5 compliant, 4,300 horsepower natural gas hybrid line-haul locomotive with 1,800 DGE (Diesel Gallon Equivalent) of on-board fuel storage. The locomotive will use multiple Cummins ISX12N engines, developed previously, to meet the applicable Federal Railroad Administration (FRA), Department of Transportation (DOT), and EPA requirements, providing an affordable and viable pathway to near-term commercialization.
The objectives of this program are to:

- Demonstrate that commercially available and reliable components can be used to manufacture affordable Tier 5 and near-zero emissions line-haul-locomotives.
- Demonstrate the use of the new, on-road, 100% natural gas, near-zero Cummins Westport ISX12N engine in rail application.
- Demonstrate that multi-engine natural gas hybrid locomotives, including the utilization of regenerative braking, can increase overall system energy efficiency and reduce fuel consumption by 20% to 40%.
- Prove Class I, II, and III railroads can reduce their fuel cost, reduce criteria pollutants, and dramatically lower GHG emissions compared to diesel by using CNG and RNG.
- Collect data to validate durability and reliability while in rail freight service.

This program aims to overcome two concurrent challenges: 1) achieving near-zero emissions operation and 2) proving multi-engine line-haul service feasibility. Reliable technology must be demonstrated for regulators and railroads to mutually agree upon a viable pathway that meets their competing goals. Data gathered during the demonstration will be freely shared with public and private stakeholders to enhance the dialogue regarding the composition of the 39,000 freight locomotives currently operating in the United States.

Approach

Since 1992, DOE's Vehicle Technologies Office has supported the development of multiple generations of Cummins Westport, Inc.'s natural gas engines for heavy-duty vehicles, resulting in a family of near-zero emission natural gas engines (B6.7N, L9N, ISX12N) in production for on-road use. These engines are proven, affordable, reliable, and have nitrogen oxides (NOx) emissions of 0.02 g/bhp-h and particulate matter (PM) of 0.01 g/bhp-h for on-road applications (i.e., in transient mode). This is 90% lower NOx emissions than the current EPA standard. In addition, in the steady state mode as a generator, the engines have EPA-certified NOx and PM emissions of 0.00g/bhp-h. In that mode, "zero emission" NOx and PM operation is possible for the rail, marine, and power generation markets. In October 2019, OptiFuel, with the support of Cummins Inc., secured EPA Rail Certification for the ISX12N as the first ever internal combustion engine to achieve 0.00g/bhp-hr NOx and PM certification. This engine will be used as the basis for the locomotive powertrain.

In Budget Period 1, the project will begin by creating detailed system specifications for the locomotive. These specifications will drive quantitative metrics to be used during systems validation and operational testing. Once the specifications have been completed and validated, engineering will begin on the locomotive design. Ordering of long-lead items will begin, as will planning and preparation for testing.

In Budget Period 2, OptiFuel will procure the base locomotive platform and continue procurement of other components (engines, generators, gas storage tanks, controls, etc.). The locomotive manufacturing will begin at Railserve in Longview, TX. During this time, the team will use feedback from manufacturing to update the designs and identify process improvements to be incorporated into the final report.

In Budget Period 3, the project team will commence system validation and application testing. This will begin with testing the locomotive systems per the requirements developed in Budget Period 1. Following that, the locomotive will be moved to the Association of American Railroads' (AAR) Transportation Technology Center (TTC) testing facility in Pueblo, CO. This testing will include:

- Dynamic and static vehicle testing.
- Three months of performance, endurance, and component reliability testing on a 50-mile, full-scale on-track testing that includes a high tonnage loop.

During the initial demonstration at the TTC testing facility, the locomotive will operate on the 50-mile test loop in real-world conditions. The operation at TTC will allow the team to perform controlled testing and gather critical data on emissions, fuel consumption, specified performance metrics, dynamic and other safety characteristics, and reliability during revenue service simulations. Testing results will be used to support approvals from FRA and EPA. Validating the performance and safety of the locomotive at the nation's premier railroad test site will provide results that can be shared with regulators and Class I, II, and III railroads across the country.

Results

The project team has made significant progress in 2023, overcoming multiple challenges stemming from COVID-19 delays in 2021 and 2022.

Throughout 2023, the team held biweekly project team meetings and weekly design meetings attended by the major component suppliers and the growing engineering staff. The locomotive and system design has evolved as follows:

Cummins has announced the commercial availability of the newest 15-liter engine X15N, offering higher output and 10% better efficiency within a comparable footprint. Considering the benefits of the new engine and the anticipated obsolescence timeline of the ISX12N engine currently considered for the locomotive, the team has decided to update the design to accommodate the X15N. The pods, when assembled together, offer a 23" x 80" walkway through the center of the locomotive (Figure I.17.2).

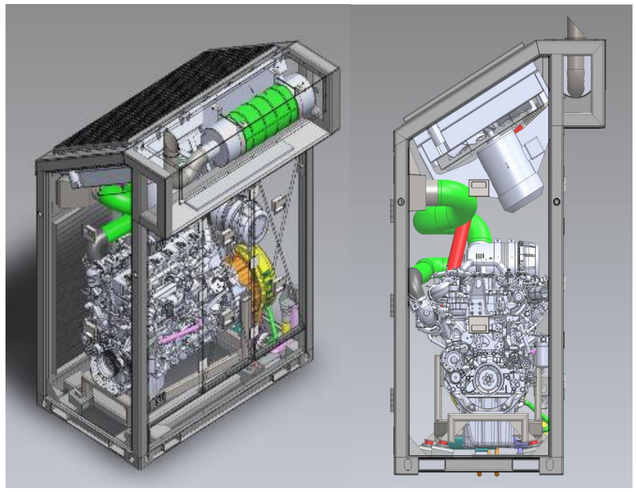

Figure I.17.2 Updated engine pod design with X15N engine

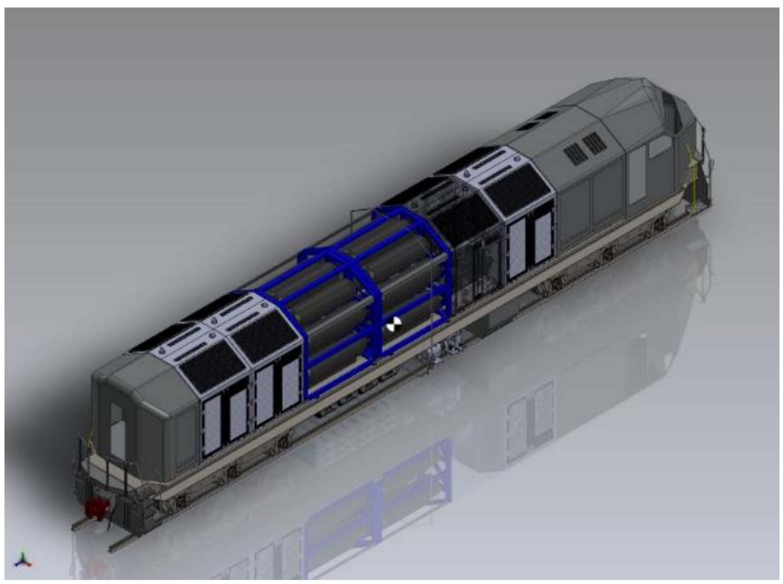

Figure I.17.3 Isometric 3D rendering of the SD90 locomotive.

Due to increased cooling requirements and airflow analysis, the engine pod arrangement and size have changed, requiring a larger locomotive platform. The team will build on an SD90M locomotive platform, which affords a more optimal layout of the modules and components on deck (Figure I.17.1, Figure I.17.3, and Figure I.17.4).

The higher engine output of 510hp (previously 400hp) enabled the reduction of required battery capacity from 1,200kW to 420kW, reducing the cost, weight, and relocation of the battery system under the deck. This change, in turn, offered additional space for engine pod packaging, improving accessibility and serviceability. The batteries will employ lithium iron phosphate chemistry for improved safety. The final performance of the locomotive is expected to offer a peak power of 4,080hp from the X15N engines plus 560hp from the battery. However, the actual loads on the representative duty cycles will be lower, ensuring 10-year useful life of the components.

The longer locomotive platform allowed for two 850 diesel-gallon-equivalent (DGE) gas storage modules to be installed on the deck, reducing the complexity of high-pressure gas piping (Figure I.1.4, Figure I.1.5). The change also improved the weight balance of the locomotive and the tractive effort capability on both trucks. The cumulative design changes required additional finite elements analysis (FEA) to ensure the structural integrity of the equipment, adding to the overall schedule slip.

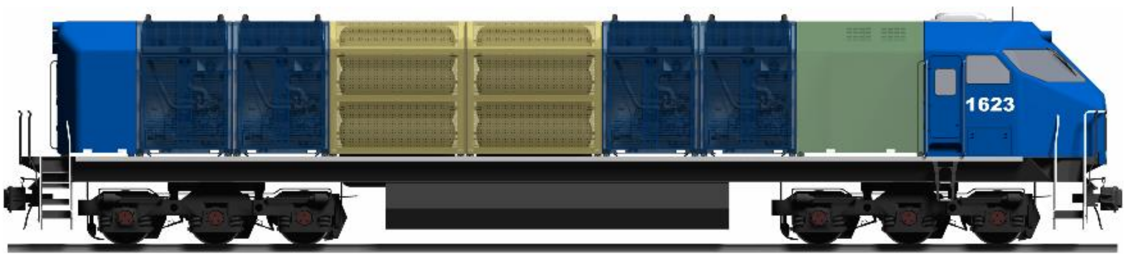

Figure I.17.4 3D rendering of the SD90 locomotive showing layout of modules. Note two fuel storage modules in the center of the platform, flanked by engine pods

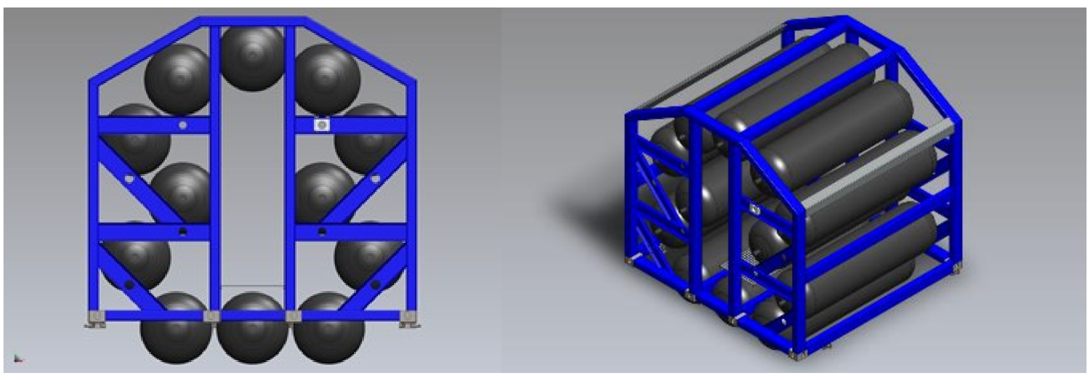

Figure I.17.5 3D rendering of the gas storage module. Note a walkway through the center of the module

An additional engineering effort has been dedicated to the development of the starter/generator. Due to a lack of a commercially available starter/generator that meets the packaging and performance requirements, OptiFuel has been collaborating with Dynamic E Flow GmbH to develop a custom permanent magnet synchronous starter/generator matched to the application Figure I.17.6 and Figure I.17.7).

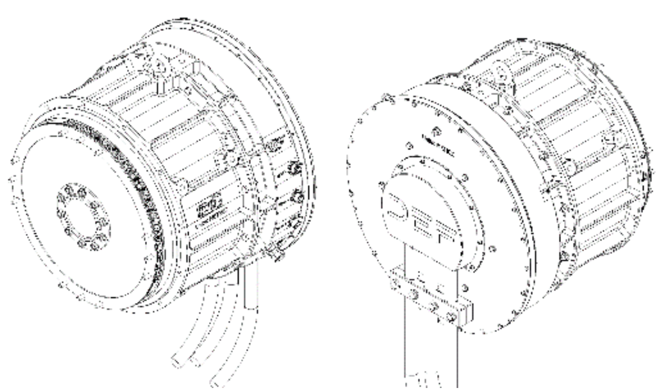

Figure I.17.6 Isometric drawing of custom starter - generator

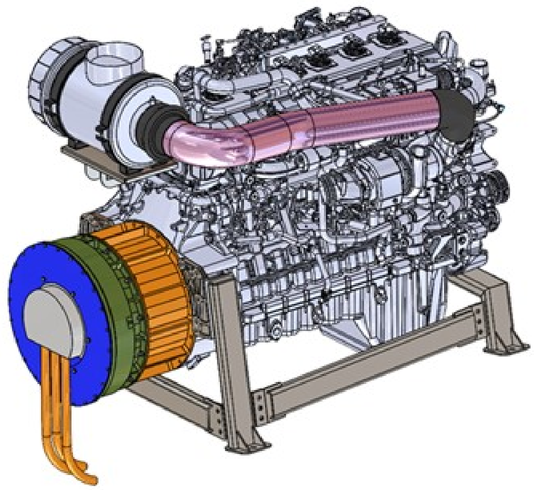

Figure I.17.7 3D Model of X15N engine with custom starter - generator attached.

OptiFuel has been working with component suppliers and Railserve on the assembly plan for the locomotive at Railserve's site in Longview, Texas. OptiFuel and Railserve have also been planning an acquisition of a used SD90 locomotive in Budget Period 2, along with ordering the long-lead items, such as pressure vessels, engines, generators, batteries, and control system. Due to the late design changes and availability of components, such as the engines and generators, the expected build schedule has moved to Q4 2024 and will be followed by technical testing and demonstration at FRA's Transportation Technology Center (TTC) Pueblo, Colorado in 2025. The team has requested a corresponding project extension.

Conclusions

At the successful conclusion of this project, the team will have demonstrated that it is economically feasible to produce and implement CNG/RNG-powered locomotives in long-haul freight service. The project is using commercially available components to design and manufacture an affordable locomotive that makes use of the 100% natural gas Cummins X15N engine. This project will quantify the reduction in emissions and increase in energy efficiency available to Class I, II, and III railroads by implementing multi-engine hybrid locomotives. The team will also analyze the capital cost and operating costs of the locomotive. The project is behind schedule, but the team expects to maintain progress in Budget Period 2 and successfully demonstrate the project objectives.

Acknowledgments

The project team would like to acknowledge the support of its DOE Project Manager, Mr. Daniel Nardozzi.

I.18 Delivering Clean Air in Denver: Propane Trucks and Infrastructure in Mail Delivery Application (Drive Clean Colorado)

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Start Date: October 1, 2020 End Date: December 31, 2023
Project Funding: $ 1,000,010 DOE share: $500,005 Non-DOE share: $500,005

Project Introduction

This project will purchase and deploy five propane-powered delivery trucks along with propane fueling infrastructure in the metro Denver area. The trucks will be Ford Class 7 (F-750) straight box trucks with Roush CleanTech ultra-low (.02 g/bhp-hr) NOx 7.3L V8 propane engines, which are new for model year 2021, commercially available across the United States, and certified by the Environmental Protection Agency (EPA) and California Air Resources Board (CARB).

The demonstration fleet, Hi Pro Inc., is in Commerce City, a close suburb of Denver. This fleet moves mail from the United States Postal Service (USPS) main hub to the individual post offices daily. Hi Pro, Inc. has a fleet of 35 vehicles in Colorado and will replace five diesel trucks with the trucks purchased as part of this project.

Project Partners:

- Drive Clean Colorado (DCC)
- Hi Pro, Inc.
- AmeriGas
- National Renewable Energy Laboratory (NREL)
- Roush CleanTech
- Propane Education & Research Council (PERC).

Objectives

This proof-of-concept demonstration of alternative fuel vehicles (AFVs) in a selected vehicle fleet will lead to improved understanding of the costs, operational issues, emission reductions, and performance attributes associated with propane vehicles, and will inform technology adoption decisions for the USPS contractors market transformation from traditional to alternative fuel vehicles. By demonstrating the advantages of propane as a clean and cost-effective alternative to diesel and its viability in the test fleet, the project will share data, best practices, and lessons learned to catalyze other fleets nationwide to adopt propane trucks for mail delivery (and other applications). By reducing the risk of first adoption, the potential exists to transform the USPS mail delivery system into a low-carbon national fleet.

The project team will study the viability of propane as a long-term fuel option in the selected market and quantify the emission reductions in the delivery duty cycle. This project fills the gap for medium- and heavy-duty fleet vehicles that have had limited demonstration of alternative fuels, and which are less suited for electrification, due to the limited and expensive electric charging infrastructure and long-range needs of delivery service vehicles operating day and night.

Approach

DCC has formed a project committee that is currently meeting once a quarter to provide updates on data capture and analysis, truck operations, performance, and maintenance, and any other issues that may arise. This allows DCC to clearly communicate next steps, celebrate accomplishments, and address any unforeseen barriers to progress.

The five trucks are operating on routes throughout the Denver Metro region on a regular basis. The fleet services the trucks regularly every eight (8) weeks for necessary maintenance and any needed repairs. The fueling infrastructure on site is operational and meets the needs of the fleet.

NREL has collected operational data using data loggers on ten Hi Pro, Inc. diesel fleet trucks and the five propane trucks in intervals. Data collection has been intermittent, starting on October 1, 2022, through September 30, 2023. Data has been collected on diesel fleet trucks from August-September 2022 and from March-May 2023. Data has been collected on the propane trucks from March-May 2023 and from July-August 2023.

This is now undergoing analysis for comparison studies and initial findings to be included in final reporting.

Results

BP3: Data Collection & Analysis

Operational data was collected using data loggers on all five propane trucks from March to May 2023, as well as two diesel trucks during the same period for direct comparison. Data has been collected on propane trucks for comparable summer data from July to August 2023.
Data analysis is now underway, including total cost of ownership analysis. Initial findings show that propane fueling costs an average of $2.03 per gallon compared to diesel prices of $3.69 per gallon on average. We expect results to be completed by December 2023.

BP3: Education & Outreach

Webinar planning and preparation began in September 2023 with the expected webinar release on October 3, 2023. The webinar will cover the purpose of the project, process of truck and fueling infrastructure acquisition, performance and operations, cost and emissions reductions, and initial data findings. See Figure I.18.1.
Social media and newsletter highlights will be promoted throughout 2023.
Promotional video design is underway, and production is expected in October or November 2023. Once published, the video will be widely shared on social media and via partner newsletters.
The Hi Pro Inc. fleet adoption of propane trucks was highlighted in an article in the Modern WorkTruck Solutions Magazine in September 2023, highlighting the cost and environmental benefits of propane adoption and Hi Pro's plans to expand their propane fleet. See Figure I.18.2.

Figure I.18.1 Webinar Advertisement

BP3: Trade Show Participation

PERC, Roush, and Hi Pro, Inc. attended the National Star Route Mail Contractors Association Convention in August 2023 and highlighted the project throughout.

Figure I.18.2 Hi Pro Propane Autogas Truck

Conclusions

As this project is still in the implementation stages, conclusions are not yet identifiable. Data analysis and total cost of ownership analysis are currently underway, and conclusions are expected to be available in December 2023.

Key Publications

Mouw, Todd, "Colorado Mail Delivery Fleet Makes a Commitment to Clean Energy: An Alternative Fuel that Makes Sense for Business." Modern WorkTruck Solutions, September 2023, Modern WorkTruck Solutions September 2023 (simplebooklet.com)/.

Acknowledgements

We want to thank our project manager, Sonja Meintsma, Drive Clean Colorado, and Hunter Woodruff, Fleet and Fuels Program Manager with Drive Clean Colorado, for their work in maintaining project cohesion and meeting DOE requirements for reporting.

I.19 Cold-Weather Operation, Observation and Learning Electric Vehicles: COOL EVs (American Lung Association)

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Start Date: October 1, 2020 End Date: December 31, 2024
Project Funding: $2,017,265 DOE share: $997,274 Non-DOE share: $1,019,991

Project Introduction

The Cold-Weather Operation, Observation and Learning with Electric Vehicles (COOL EVs) project supports the deployment of four battery electric vehicles (EVs) in three community fleets in the metropolitan area of Minneapolis/St. Paul. This project is strategically designed to overcome the challenges of cold weather operation, which is crucial to advance EV fleet applications. The four EVs included in this application are a rear loader refuse hauling truck, two box trucks for supplies delivery, and a school bus. The fleets will share some resources, including training, technology, and project management support.

Existing applications of heavy-duty EVs have shown that very cold weather can result in lower energy efficiency, lowering the overall available range. Minnesota has a continental-type climate and is subject to frequent outbreaks of continental polar air throughout the year, with occasional Arctic outbreaks, and intermittent periods of prolonged heat. The lack of widespread experience with EVs has presented challenges for fleet operators, as there are specific operating characteristics and fueling requirements associated with these deployments. The results of this demonstration will provide invaluable information to the medium- and heavy-duty EV industry about extreme weather performance, and how deployment and operational strategies for these vehicles can be optimized to overcome the challenges of extreme weather operation.

The identified solutions in this project are the result of years of work by project partners, and additional contributions, insights, and lessons from actual heavy-duty EV deployments. This project combines the experience and capabilities of three unique fleets, Minnesota’s largest electricity provider, and two national 501(c)3 non-profits, including the Minnesota Clean Cities Coalition (MC3), to develop an electric proof-of-concept in three communities and fleets that will rapidly advance the sustained use of EVs in Minnesota.

Objectives

The objective of COOL EVs is to demonstrate four unique EVs and electric vehicle supply equipment (EVSE) infrastructure in three community fleets in the metropolitan area of Minneapolis/St. Paul. The project documents and shares knowledge across the value chain of medium- and heavy-duty EV deployments by providing insight into the impacts that cold weather operation have on vehicle performance. When this project kicked off there were no EVs in refuse hauling fleets in Minnesota. The battery electric school bus would be the first in its large district. Project objectives include:

- Deploy the following EVs and EVSE: two box trucks to University of Minnesota, an 84-passenger school bus to Eastern Carver County Schools, and a side loader refuse truck to Eureka Recycling.

- Prepare Performance Monitoring Report and conduct Community-based Outreach and Collaboration including first responder trainings, high voltage safety trainings, Key Performance Indicator (KPI) workshop, ride and drives, case studies, and promotional, training and outreach materials for tradeshows and presentations.

- Eliminate over 390,000 lbs. of greenhouse gas emissions and displace 17,024 gallons of diesel per year.

Approach

The COOL EVs initiative champions the efforts of fleets already committed to innovation and environmental benefits and will accelerate the growth of EV applications in these fleet types, as well as other fleet types that operate in cold-weather climates. The American Lung Association and MC3 rely on the enthusiasm of their fleet partners and project partners, Center for Transportation and the Environment (CTE) and Xcel Energy, to deploy and study these vehicles in different operating environments, evaluate the vehicles' ability to perform at the same level of operation as similar gasoline, diesel, and propane vehicles, and evaluate performance metrics and environmental benefits based on actual operation.

Through a comprehensive analysis of the vehicle performance data, best practices, policies, procedures, and scalability of each of these unique deployment applications, the project team has begun to draw conclusions that will prove relevant for organizations of all types, sizes, and experience levels. This will increase the likelihood of successful medium- and heavy-duty EV deployments in the Twin Cities and throughout the state, and by fleet operators in other cold-weather climates. Each of the fleet operators on the project team has demonstrated successful proof-of-concept projects in the past eighteen years and is ready to invest in EVs. Vehicles participate in a variety of community events showcasing the benefits of electrification. One example is the electric school bus participating in the daily parade at the Minnesota State Fair parade as shown in Figure I.19.1.

Figure I.19.1 School bus participates in Minnesota State Fair August 2022

The project team is working to complete a total of four workshops to train fleet operators' staff and first responders on the safe and efficient operations and maintenance of the vehicles and has completed three EV ride and drives to also introduce fleet organization employees to light-duty EVs. Project partners have attended several conferences, trade shows and/or expos to promote the project. The American Lung Association anticipates capturing five million media impressions while executing the Training and Outreach Campaign. The campaign has targeted the general public, fleet decision makers, and first responders. All EVs are certified by the U.S. Environmental Protection Agency (EPA) and/or the California Air Resources Board and meet applicable Federal Motor Vehicle Safety Standards for on road use.

Throughout the project, the COOL EVs team has been documenting project successes and lessons learned to strategically identify best practices and effective vehicle deployment strategies for cold weather operation, to deliver a comprehensive case study at the close of the project. To accomplish this objective, and ensure that the project can be replicated by other fleet operators across the U.S., the project team will focus on three major activities as follows:

- Deployment of EVs and Infrastructure.
- Comprehensive Community-based Outreach and Collaboration.
- Evaluation of Fleet Performance and Analysis of Seasonal Impacts.

Results

The project went through fleet changes early on. Originally the project included Allina Systems, which backed out of the project in 2021 due to pandemic issues and staffing capability. The PI and partners developed a process to request a new fleet to fill the gap. The partners interviewed 12 fleets interested in participating in the project. Due to the interest and funding of partners MC3 staff chose to include two fleets to replace Allina Systems in late 2021. The fleets were to include the University of Minnesota waste program and Arrowhead Transit in the northern rural region of Minnesota. As of the close of 2021 Arrowhead was non-responsive which led to the prime and partners choosing to award two vehicles to only one fleet (University of Minnesota).

The first fleet vehicle purchased in the project was an electric 84 passenger Blue Bird School Bus for Eastern Carver School District. The bus has been on Minnesota roads since August 2021. The bus has been active in the school district and has been showcased at a variety of events. The order included Level 2 EVSE. CTE and the school district completed route optimization early in the project but had some challenges with telematics data.

The electric bus has been driven nearly 20,000 miles. It has a battery capacity of 155 kWh with a Cummins PowerDrive 7000 Propulsion System and has an advertised range of 120 miles, but typically has about 100 miles in summer and just over 60 miles in winter. The charger is a Clipper Creek Level 2.

Overall, the school district is happy with the bus. Minor repairs were needed in Spring 2023. It took almost two months to get the part for one repair, but all repairs were covered under warranty. Figure I.19.2 shows the miles driven and energy used by the bus between June and September 2023. Figure I.19.3 shows the battery pack on the bus and the Level 2 Clipper Creek charger which is installed in the facility’s garage.

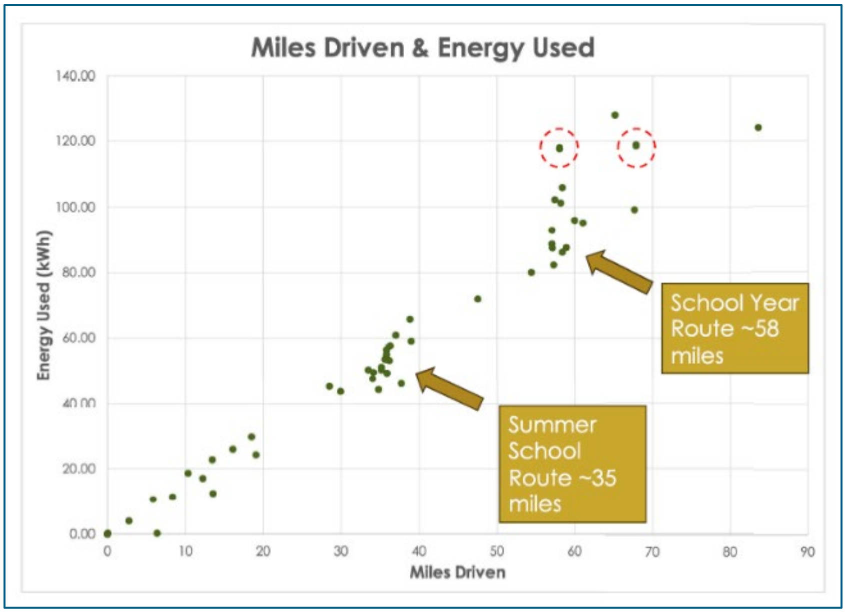

Figure I.19.2 BEV bus driven June - Sept 2023 showing miles driven & energy used.

Figure I.19.3 Blue Bird bus battery compartment (left), Clipper Creek Level 2 charger (right)

The average summer consumption is 1.6 kWh/mi. This equates to a range of 77.5 miles assuming 80% of the 155 kWh battery is useable. The best efficiency experienced was 1.22 kWh/mi, which would equate to a range of 101 miles, assuming 80% of the battery is usable. The worst efficiency experienced was 2.03 kWh/mi which would equate to a range of 65 miles. Temperature trends will develop as partners monitor data into colder months. Table I.19.1 shows data of miles driven, energy consumed, average fuel economy, days driven, and number of charge events.

Table I.19.1 Eastern Carver County School District Electric Bus KPI Report

	June 2023 (June 20 - 30)	July 2023 (July 1 - 31)	August 2023 (August 1 - 31)	September 2023 (September 1 - 30)
Miles Driven	342	453	230	893
kWh Consumed	519	690	318	1450
Average Fuel Economy	1.49 kWh/mi	1.54 kWh/mi	1.44 kWh/mi	1.59 kWh/mi
Days Driven	7	15	6	18
Number of Charge Events	9	14	11	31

Data from August 2021 – May 2023 via Geotab was corrupted while reviewing with partners. The initial data exports from Geotab showed that the data was not reporting properly. Eastern Carver School District and CTE attempted to troubleshoot via email for several months in early 2023. CTE hosted a meeting with Eastern Carver County Schools to discuss the specific issues for them to take to their telematics technology provider (Tyler Technologies).

The meeting led to CTE being connected to Tyler Technologies, ECC's data services provider, in May 2023 where Geotab permissions were granted to Tyler Technologies. Geotab had to reset a device setting in June and Eastern Carver County fleet was able to pull a report with useable data at the end of June. As of late June, CTE had been granted access to GeoTab.

Table I.19.2 shows a comparison of the battery electric bus to the base fleet average for the more than 50 propane buses listed as "Route buses."

Table I.19.2 Base Fleet Comparison of Battery Electric Bus (BEB) to Base Fleet Average

	June 2023		July 2023		August 2023		September 2023	
	BEB	Base Fleet	BEB	Base Fleet	BEB	Base Fleet	BEB	Base Fleet
Daily Miles (when driven)	49	56	30	59	26	44	47	80
MPG—E	22.8	3.8	20.6	4.1	21.6	4.0	21.8	4.0
Trips Per Bus	7	2	15	4	6	3	19	19

Eureka Recycling and project partners received delivery of the electric waste hauler from Battle Motors in December 2022 but within less than one week Battle Motors recalled the truck due to electrical issues. The truck has been delivered as of September 2023 as shown in Figure I.19.4, but there are still several remaining issues, and the timeline for addressing the issues has been extended multiple times. Battle Motors recommended using a Positive Energy Charger, shown in Figure I.19.5, but it has yet to successfully connect and charge the truck. Discussions between Battle Motors, Positive Energy, and BorgWarner about the issue continue.

Figure I.19.4 Eureka Electric Refuse Truck

Figure I.19.5 Positive Energy DCFC

The **University of Minnesota** took delivery of two box trucks built by Allstate Peterbilt Group (MY 2024 Model 220) in July and September 2023. See Figure I.19.6 for box truck and wrap. The fleet experienced minimal issues related to the licensing of the two vehicles which has led to delays of the trucks being on the road. As of the end of September 2023, the University continues to experience delays with the charging equipment. Xcel Energy is continuing to wait for a code inspection so the final connection and commissioning can be completed.

Figure I.19.6 Peterbilt 2024 220e box truck

Project partners continue to collaborate on education and training for new fleets in Minnesota that are considering future electric vehicle deployments. Immersed Technologies led the High Voltage Training in Saint Paul, Minnesota in April 2023. Three fleets and seven project fleet operators attended along with staff from CTE and MC3. MC3 and partners hosted ride and drives for fleet employees in May and July 2023. In May the ride and drive and EV showcase were held on the Minnesota State Capitol grounds with over 100 attendees. Fleets from the Twin Cities metro area and across the state attended.

The MC3 team provided support and co-hosted the Ramsey County Fleet Showcase on July 13, 2023. Light-, medium-, and heavy-duty vehicles included an electric street sweeper, electric Zamboni, and electric tractor, along with various off road electric and propane equipment. Unfortunately, the box trucks and electric waste hauler were delayed and not available for display. Fleet staff completed 36 test drives/rides. Fifteen vehicles were available at the event. Due to requests from planning fleet members a variety of light-duty vehicles and commercial level electric landscape equipment were also at this event. Survey insights note that while all fleet staff attending were familiar with EVs, none owned a personal EV. Over 50 fleet staff RSVP'd with about 35 attending on a very hot afternoon. 19% of respondents had no experience with an EV. Attendees noted that they wanted to see more trucks at the event and 40% stated the most beneficial aspect of the event was time talking to vendors.

Conclusions

The COOL EVs project has brought multiple unique and innovative fleets together, capitalizing on opportunities to consolidate training, performance monitoring, outreach and communication, and project management capabilities in 2022 – September 2023. These synergies continue to reduce costs and allow fleet operators in the community and across the region to share lessons learned and best practices.

The COOL EVs initiative champions the efforts of fleets already committed to innovation and environmental benefits and will accelerate the growth of EV applications in these fleet types, as well as other fleet types that operate in cold-weather climates.

The COOL EVs project partners training and outreach initiative will continue to address needed outreach, education, and coordination among key local and regional partners, and disseminate information regarding the use of EVs. The project team will provide a final set of training for first-responders, service technicians, mechanics, code officials, and managers to ensure safety while utilizing and responding to a variety of situations involving EVs.

Through a comprehensive analysis of the vehicle performance data, best practices, policies, procedures, and scalability of each of these unique deployment applications, the project team has begun to draw conclusions that have proved relevant for the partner fleet operators.

I.20 St. Louis Vehicle Electrification Rides for Seniors (Forth)

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Start Date: October 1, 2020 End Date: March 31, 2024
Project Funding: $1,032,392 DOE share: $500,000 Non-DOE share: $532,392

Project Introduction

The goals of the St. Louis Vehicle Electrification Rides for Seniors (SiLVERS) project are to increase EV adoption and to reduce transportation-related operating expenses for social service agencies in low-income communities. The project seeks to increase EV adoption by (1) validating that EV fleets can save social service agencies money on transportation operation costs while improving service delivery, (2) providing access to electric vehicle supply equipment (EVSE) for employees and community members, and (3) developing tools and best practices for use by community-based organizations (CBOs) and social service agencies nationwide, allowing them to replicate this approach.

The project addresses multiple existing conditions that require improvements. First, the industry norm is that one private charger serves just one vehicle. Second, there is limited availability of fleet vehicle chargers at workplaces. At workplaces where EV chargers are available, access to the chargers is often restricted. Third, the overall EV adoption rate in St. Louis is very low. Fourth, CBOs in low-income neighborhoods may lack access to information about EVs and have comparatively low access to EVs and the economic and environmental benefits they provide.

SiLVERS provides EVs and associated EVSE to two community centers, Northside Youth and Senior Service Center (NSYSSC) and City Seniors, Inc. (CSI), located in North and South St. Louis, respectively. These agencies provide non-emergency rides to elders and distribute food to homebound seniors. Additionally, the project seeks to expose the local community to the economic and environmental benefits of driving electric. The EVSE software platform enables community members to access the chargers when not in use by the CBOs’ fleet vehicles.

Showcasing a sustainable model for small CBOs to operate EVs as part of their fleets and host publicly accessible EVSE is a use case that has not been fully explored as an opportunity to decrease transportation emissions and increase EV adoption.

Objectives

This pilot of five EVs and five chargers has the following objectives:

1) Measure the extent to which EV fleets can save CBOs or social service agencies money and improve service delivery.
2) Create a model for deploying EVSE that can serve CBO or agency fleets and can also serve CBO or agency employees and other community members.
3) Show that pilots like this can accelerate regional EV adoption.
4) Create tools and best practices so this model can be replicated by CBOs and agencies nationwide.

These objectives aim to create the following outcomes:

1) Adoption of this model by additional CBOs and agencies.
2) Improved skills and capacity of CBOs and agencies to manage their EV fleets; optimized charger usage; and reduced operating costs.
3) Increased EV adoption in the St. Louis market.

Approach

Budget Period 1 (October 1, 2020 – December 31, 2021) Summary

The first project budget period was used for project development and launch. First, Forth assembled the project partners. Forth established a partnership with the St. Louis Area Agency on Aging (SLAAA), a government entity that provides funding to private CBOs that serve the St. Louis elderly population. Forth selected NSYSSC and CSI as the two participating CBOs because both organizations serve traditionally low-income areas, and to ensure that CBOs in both North and South St. Louis were included in the project. North St. Louis, where NSYSSC is located, has a large majority of Black residents.

Three vehicles and dual port charging stations would be located at NSYSSC, and two vehicles and dual port charging stations would be located at CSI. The team selected EV charging network provider ampUp for its ability to both provide charging station data and integrate directly with onboard vehicle telematics to gather vehicle data. Forth, via a Request for Proposals, also identified a local electrician to perform the station installation. Forth performed a fleet requirements identification and a transportation assessment to select vehicles for the project. Given constraints at the time, Chevrolet Bolts (leased) were selected as project vehicles. Vehicles and charging stations became operational in November of 2021, at which time Forth and project partners began collecting data.

Budget Period 2 (January 1, 2022 – December 31, 2022) Summary

In the second budget period the project focused on CBOs commencing utilizing the EVs for service delivery, measuring impact, disseminating project design and results, and developing tools for reproduction. The current roster of tools can be found on the SiLVERS webpage. Members of the project team participated in several webinars, conferences, and workshops for the SiLVERS project.

Budget Period 3 (January 1, 2023 – September 30, 2023) Summary

In the third and final budget period the project has maintained the focus areas outlined in the Budget Period 2 Summary. Project staff attended several more conferences and workshops. Further, Forth has provided technical assistance via calls and virtual meetings with organizations interested in the SiLVERS project. The third budget period will culminate in the production of a final case study. The Forth team has established the "SiLVERS Clean Cities Coalitions Working Group" in association with St. Louis Regional Clean Cities (SLCC), Greater Indiana Clean Cities, and Michigan Clean Cities, to explore how to replicate or scale a SiLVERS-like project in their respective geographies.

In September 2023, SiLVERS was featured on PBS' *MotorWeek*, an award-winning automotive-focused television program broadcast to hundreds of stations across the U.S. with 429,000 direct subscribers.

SLCC has continuously supported this project by providing technical and strategic advice to Forth and the project team and contributing to key deliverables. This includes attending monthly regional calls, Air Quality Advisory Committee meetings, car club meetings, and conferences, and engaging with dealerships, board members, and local stakeholders. Across 39 meetings, audiences have ranged from 8 to 350, averaging around 25 attendees. SLCC has estimated that they have reached 650 people in person and an additional 10,000 through media. See Table I.20.1.

Table I.20.1. Conferences, Webinars, and Workshops Attended by Forth Staff Between October 1, 2022, and September 30, 2023

Event and Presenter	Description
The TEEM (Towards Equitable E-Mobility) National Call Virtual - *March 2023* Connor Herman, PI, Forth	Presentation to about 30 TEEM member organizations from the 8 TEEM states on project design and delivery.
U.S. Climate Alliance Meeting Virtual - *March 2023* Kelly Yearick, Senior Program Manager, Forth	Presentation to about 30 state employees from various Northeast states about carshare programs,including SiLVERS, potential for collaboration/integration with Advanced Clean Cars (ACC) II rulings
Urbanism Next Portland, OR – *April 2023* Stefanie Griggs, Program Manager II, Forth	90-minute panel with Juan Serpa Munoz (Eugene Water and Electric Board), Alan Hipolito (Suma), and Stefanie Griggs (Forth) moderated by Tomas Endicott (BEF), on carshare program designs, including SiLVERS.
American Public Human Services Association Summit Baltimore, MD - *May 2023* Jennifer Zavon, Senior Program Associate, Forth	60-minute session titled “Cost Saving and Climate Friendly Service”, which included a presentation and Q&A between Jennifer Zavon (Forth) and Shana Watson (Northside Youth and Senior Service Center) on SiLVERS project design and delivery.
Green Transportation Summit and Expo Tacoma, WA – *August 2023* Connor Herman, PI, Forth	30-minute learning session hosted by Connor Herman (Forth) specifically focused on SiLVERS project design and delivery.
Senior Workshop St. Louis, MO – *September 2023* Jennifer Zavon, Senior Program Associate, Forth	Hosted by Jennifer Zavon (Forth), this session interacted specifically with seniors who have used the project EVs, gathering anecodatal data on their experiences.
Show Me Summit on Aging and Health Columbia, MO – *September 2023* Jennifer Zavon, Senior Program Associate, Forth	60-minute session titled “Cost Saving and Climate Friendly Service” which included a presentation and Q&A between Jennifer Zavon (Forth) and Anneliese Stoever (St. Louis Area Agency on Aging) on SiLVERS project design and delivery.

Results

Program vehicles continue to be used heavily to provide services. A summary of utilization data from October 1, 2022, through September 30, 2023, is provided in Table I.20.2.

Table I.20.2. Utilization Metrics, October 1, 2022 – September 30, 2023

	Q4 2022	Q1 2023	Q2 2023	Q3 2023
Number of Meal Deliveries	3,666	4,655	3,757	3,583
Number of Rides Provided to Seniors	333	144	307	1,101
Number of Charging Sessions	272	284	242	309
Number of kWh recorded for vehicle charging	5,376	5,932	4,094	6,176
Estimated lbs. of CO2 avoided	8,602	9,491	6,551	9,882

The five program vehicles have been driven 103,000 miles since the beginning of the program. Preliminary findings suggest at least $2,400 in fuel savings per vehicle per year. Forth will prepare a detailed report of the total cost of ownership in Q1 of 2024. Most vehicle drivers responded that most or all needs associated with meal delivery and providing rides were met with the project vehicles, as shown in Figure I.20.1 and Figure I.20.2.

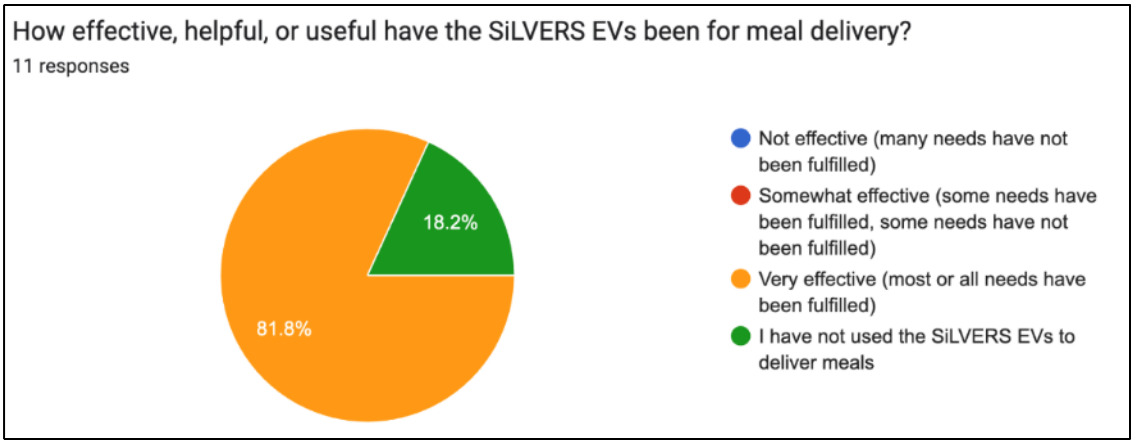

Figure I.20.1 Driver Survey Responses on Usefulness of Project Vehicles: Meal Delivery

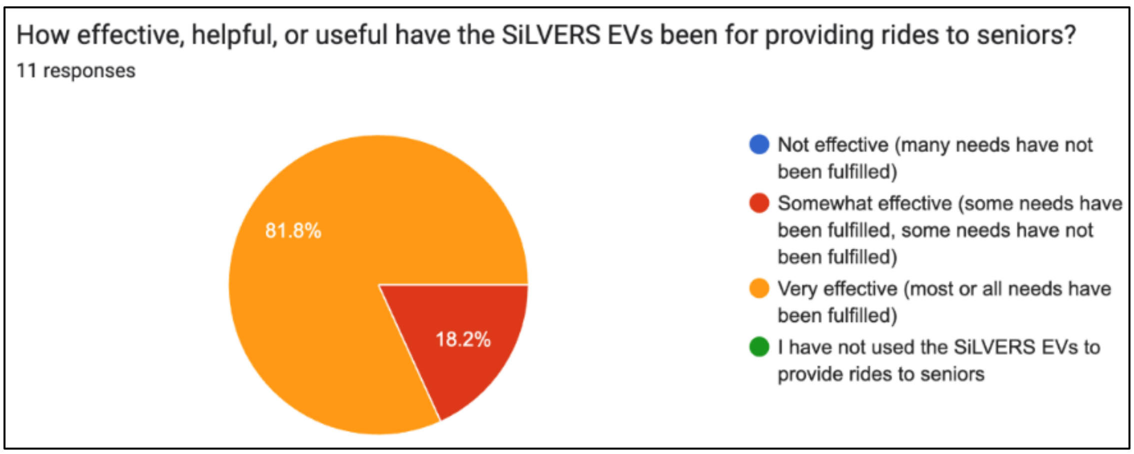

Figure I.20.2 Driver Survey Responses on Usefulness of Project Vehicles: Rides

Conclusions

After nearly two years of project implementation and data gathering, the project is going according to plan. While there have been some challenges with vehicle recalls, down charging networks, and staffing shortages for CBO drivers, the vehicles have been used effectively. Results to date show behavior changes on both the individual and business levels for CBO staff and volunteers in utilizing program vehicles. There have been several opportunities to share program learnings and project development throughout the last year.

The information dissemination and tool creation that began last year will continue to expand and will conclude with a final case study in Q1 of 2024.

Acknowledgements

Forth would like to acknowledge the following current project team members:

Daniel Nardozzi – Department of Energy, National Energy Technology Laboratory

Anneliese Stoever – City of St. Louis, MO

Shana Watson – Northside Youth and Senior Service Center

Jennifer Bess – City Seniors, Inc.

Kevin Herdler – St. Louis Regional Clean Cities

I.21 Pilot Heavy-Duty Electric Vehicle (EV) Demonstration for Municipal Solid Waste Collection (Municipality of Anchorage)

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Start Date: October 1, 2020 End Date: December 31, 2023
Project Funding: $1,978,568 DOE share: $689,659 Non-DOE share: $1,288,909

Project Introduction

In partnership with the U.S. Department of Energy, the Department of Solid Waste Services (SWS) for the Municipality of Anchorage is implementing a pilot demonstration of two heavy-duty electric refuse trucks and a medium-duty electric box truck. In addition, SWS will partner with the Alaska Energy Authority and eCamion, Inc. to install and test a direct current fast charging (DCFC) station that will slowly charge a battery during the day and charge both refuse trucks at night. This will mitigate costly demand charges ($20/kW). Heavy-duty electric vehicles (EVs) are gaining recognition globally as an attractive alternative to their diesel-fueled counterparts. Fuel and maintenance savings can offset the higher upfront costs of heavy-duty EVs, making them cheaper than a diesel or natural gas vehicle over the life of a vehicle. This project will showcase the benefits of medium and heavy-duty EVs in fleets, particularly for the well-matched use case of municipal solid waste collection. Data and analysis produced as part of this project will provide a compelling case study in heavy-duty EV deployment that will encourage EV adoption across the state of Alaska and beyond.

Objectives

The objective of this project is to demonstrate an advanced technology fleet of five or fewer vehicles and supporting infrastructure in communities, fleets, or areas that have no or little experience with these technologies. Analyzing and sharing data from an arctic state will help communities in other cold climates make decisions about EVs within their fleets. This project also addresses costly demand charges which are relevant to many fleets. Objectives include:

- Acquire and install equipment.
  - Purchase two Peterbilt 520EV electric garbage trucks and a Peterbilt 220EV electric box truck.
  - Purchase and install electric vehicle supply equipment (EVSE) with battery backup; program for optimized charging times for both heavy-duty EVs.
  - Purchase and install a ChargePoint CPF50 station for the electric box truck.
  - Incorporate the medium-duty electric box truck and heavy-duty EVs into daily use.
- Monitor pilot deployment and maintain equipment.
  - Collect and analyze data from integrated software; produce quarterly analysis reports.
  - Provide project data to local and statewide fleet managers.
  - Compare performance to manufacturer claims and document in quarterly reports.

- Offer private demonstrations, test drive opportunities, and reporting of lessons learned, best practices, and case studies to fleets in Anchorage and beyond.

Approach

After extensive research and discussions with heavy-duty EV manufacturers, Solid Waste Services committed to purchasing and deploying a Peterbilt 220EV and two 520EVs. The Peterbilt 520EV is a product of a partnership between Peterbilt and Meritor, Inc, while Peterbilt partnered with Dana, Inc. to manufacture the 220EV. All SWS's current heavy-duty vehicles are manufactured by Peterbilt, and SWS technicians have extensive experience working on Peterbilt trucks.

SWS chose eCamion Inc. to provide a battery-based solution for the 520EVs. The battery will slowly charge during low demand hours and then will be used to supplement the electrical grid when demand is high during business hours. The station will ensure the draw of electricity from the grid never exceeds a preset threshold, thus avoiding high demand charges.

In a partnership with the Alaska Center for Energy and Power (ACEP), SWS will investigate whether EVs are appropriate for heavy-duty fleet applications for the Municipality of Anchorage and other cold climate communities. Deployment of these technologies will help address challenges faced by Alaska to widespread EV adoption and EVSE deployment. Additionally, this project will test the functionality and assess the value of a battery-tied fast charging station.

The knowledge gained from the demonstration of medium- and heavy-duty EVs as well as battery supported EVSE will benefit other fleet owners and EV stakeholders seeking to build out Alaska's EV charging corridor where distribution level infrastructure is limited. This knowledge can also be applied to other cold and/or sparsely populated regions.

Results

SWS took delivery of Peterbilt's first production electric vehicle in June 2021. SWS installed a ChargePoint CPF50 station in the warm storage facility at the current Central Transfer Station and charges the Peterbilt 220EV overnight. A charge takes 7-9 hours based on the truck's daily duty-cycle.

SWS drivers have put the truck into operation. There was a change in the Principal Investigator (PI) and the team implemented a new effort to streamline communication between the mechanics, driver, and PI. The new PI created a driving log that is stored in the 220EV to document activity, issues, and resolutions. Drivers identified some specific issues that are possibly specific to cold weather states:

- Regenerative brakes must be disabled during winter months due to the inability to control braking, particularly on icy roads. Abrupt braking is not safe.
- When easing off the gas pedal, truck performance is affected, as it causes the truck to slow down. There is some speculation that there are safety sensors that are causing the truck to "jump"; maybe it is sensing bumps in the road caused by snow accumulation. Drivers must get used to this feature prior to driving in icy, inclement conditions.
- The push button shifter cannot shift quickly between gears and must go into neutral gear before proceeding. This can cause a pause in reaction time, which is a concern.

Figure I.21.1 SWS's Electric Vehicle Supply Equipment (EVSE) battery and charger installed by eCamion located at the new Central Transfer Station November 23, 2022. Photo Credit: Kelli Toth

Figure I.21.2 SWS's EVSE charging stations. Members of the team from eCamion were on site to inspect the installation located at the new Central Transfer Station November 23, 2022. Photo Credit: Kelli Toth

On November 23, 2022, the EVSE was installed at the Anchorage Central Transfer Station campus. See Figure I.21.1. and Figure I.21.2. The EVSE installation is comprised of a 180 KW Battery Energy Storage System (BESS) situated on the exterior of the Warm Storage building and two 150KW rapid chargers inside the vehicle bays. The Anchorage Municipal Authority Having Jurisdiction (AHJ) identified several concerns with the BESS system's location and installation. To address these concerns, SWS is collaborating with the vendor, consulting engineers, and local authorities.

The primary concerns raised by the AHJ pertain to the BESS unit's location and its internal fire suppression components. The BESS unit, positioned under the awning of the Warm Storage building, does not meet the required separation distance from the building as stipulated by NFPA 855 4.4 and IFC 1206.2.8.2. Possible solutions include relocating the unit or installing suitable fire barriers between the unit and the building. Furthermore, the fire suppression system, smoke detection system, and fire panel within the BESS cabinet do not adhere to the stipulated UL and NFPA standards. To rectify this, the vendor is partnering with its fire suppression provider, Fike, to create a system that meets all standards. Once this compliant system is developed, it will replace the current one. On a positive note, the vender Jule/eCamion recently obtained the UL9540A Thermal Runaway Standard certification for the BESS Fire Suppression System and is actively addressing the remaining standards.

The BESS and its associated chargers remain de-energized until a satisfactory solution is in place. Currently, there is no immediate demand for this equipment since the two trucks have not yet arrived, and the local electric company has not yet implemented peak charging times.

The month of December brought unprecedented amounts of snowfall to the City of Anchorage. Several of the curbside collections trucks were unable to operate until snowplows were able to clear the streets for a few days, resulting in a delay of service for curbside residents. One observation: because the battery is mounted on the undercarriage of the 220EV, the truck has a low clearance. This caused difficulty driving the truck for weeks until streets were maintained without any additional snow accumulation. Figure I.21.3 depicts the low clearance of the truck in relation to the street, the height of the original snowbank, and the resulting melting secondary pile just below it. As the snow would melt from the higher snowbank, a secondary bank would emerge. The turning radius and low profile of the 220EV box truck was problematic and a sizable pile of snow located in the middle of cul-de-sacs caused a struggle for operators. After several weeks of street maintenance efforts by the city, normal operation resumed. It should be noted that SWS does not have a similar Internal Combustion Engine vehicle in their fleet to compare performance or specifications.

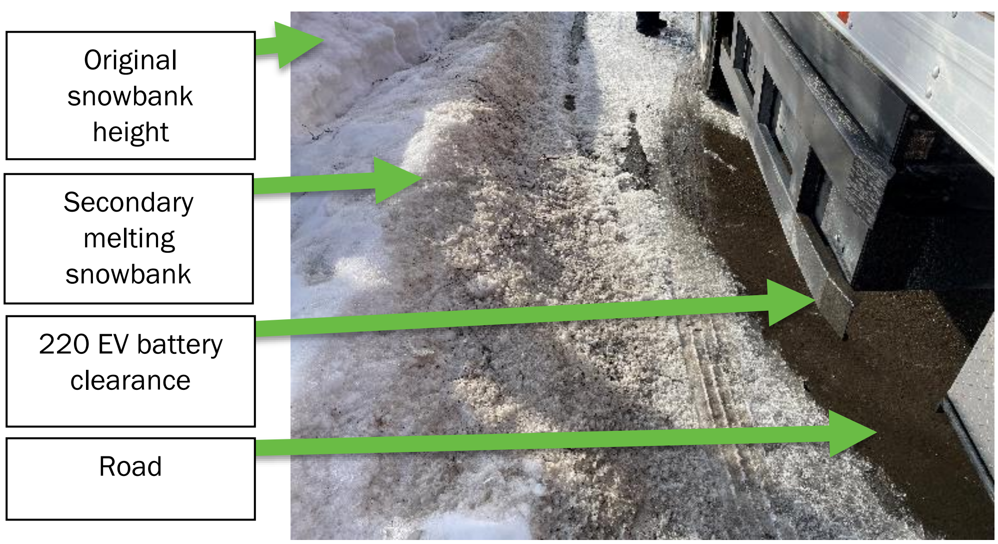

Figure I.21.3 SWS's 220EV box truck on bare asphalt next to a massive snowbank and secondary melted snowbank depicting low clearance of the battery mounted on the undercarriage, December 2022. Photo Credit: Kelli Toth

The project team is currently troubleshooting the following issues during winter months. Several times warning messages appeared; however, most were resolved. The following points are not an exhaustive list of issues, but indicate some of the most concerning:

- In colder winter months, the driver must put the heater in recirculate mode because the truck does not react well to pulling cold air into the intake system. The team is conducting a thermal test on the heater.
- The team is investigating the battery's charging and performance. The percentage of battery life that is displayed on the main monitor is not consistent with what is displayed on the gauge. For example, the monitoring screen shows 60-70%, however the gauge shows 100% full. This discrepancy causes driver hesitation because they do not want to end up with a dead battery in the field. A few times the truck has come back in the red zone.
- There are questions as to how much energy is restored to the battery when using the regenerative brakes. During the winter months the regenerative brakes are disabled, and the team is investigating whether that is the reason the truck comes back in the red zone.

The team regularly monitors and evaluates the performance of the 220EV for issues and efficiency. The 220EV was in the mechanical shop nine different times for various issues, including the following:

- The alternator had high voltage issues.
- The shop replaced a DC battery.
- High voltage wires were rubbing, and the shop put shielding in place.
- The shop replaced a clock spring, did several software updates, installed a reverse camera, and installed a resistor and shock absorber kit.

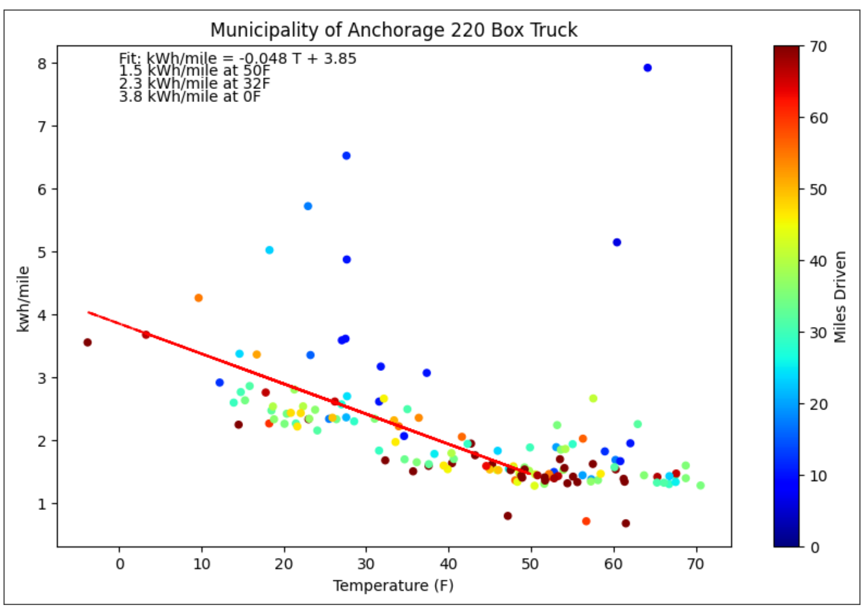

Figure I.21.4 Plot of energy consumption(kWh/mile) vs. ambient temperature (F). Linear fit line for temperatures below 50F. Temperature data was sourced from hourly temperature data at Merrill Field from www.NOAA.gov. Charging data used to find energy consumption was downloaded from the MOA Chargepoint account. Telematics data to find miles traveled is from Dana. Data ranges from 06-18-2021 - 06-30-2023. Color of data points corresponds to miles traveled between charges.

ACEP analyzed the telematics from the 220EV box truck. See Figure I.21.4. As seen in the best fit line, energy consumption, measured in kWh per mile, increases as temperature decreases. The truck's energy consumption reaches an approximately constant value above about 50°F.

The graph also includes a color map of the miles driven for each trip on the graph. The shorter trips tend to have a higher variability of energy consumption and overall high energy consumption at colder temperature than longer trips at similar temperatures.

Modeling using this data shows that this truck, if driven 5200 miles per year in Anchorage, would use approximately 10,841.34 kWh. At $0.11/kWh, this would cost **$1242** to charge, and emissions from electricity generation would be approximately **5645 kg CO2eq**. This is a correction from previous reporting based on a units conversion in the data.

Assuming the charger uses 10 kW, this could also add **$2640** in demand charges to the yearly cost of charging if charging was coincident with existing peaks. This is unlikely to be true with overnight charging and could be managed to reduce or eliminate these costs.

An equivalent diesel fuel truck with year-round average fuel efficiency of 7 mpg (this may be generous) and fuel prices of $4/gallon would cost **$2,970** to fuel and would emit approx. **7,570 kg CO2eq.**

Data analysis by ACEP also investigated heat settings in relation to kWh/mi. Figure I.21.5 is like the kWh/mile vs. ambient temperatures with miles driven coloring seen in Figure I.21.4. However, this graph has a color mapping using the average heater setting between charges. As expected, higher heater settings are seen in trips during colder temperatures. Some higher heater settings can also be seen at higher temperatures, with the energy consumption slightly higher than usual as well. Nothing conclusive can be determined, however, regarding whether a higher heater setting affected the energy consumption of these trips at warmer temperatures, as there are also trips with much lower heater settings at similar temperatures that have a similar or higher energy consumption.

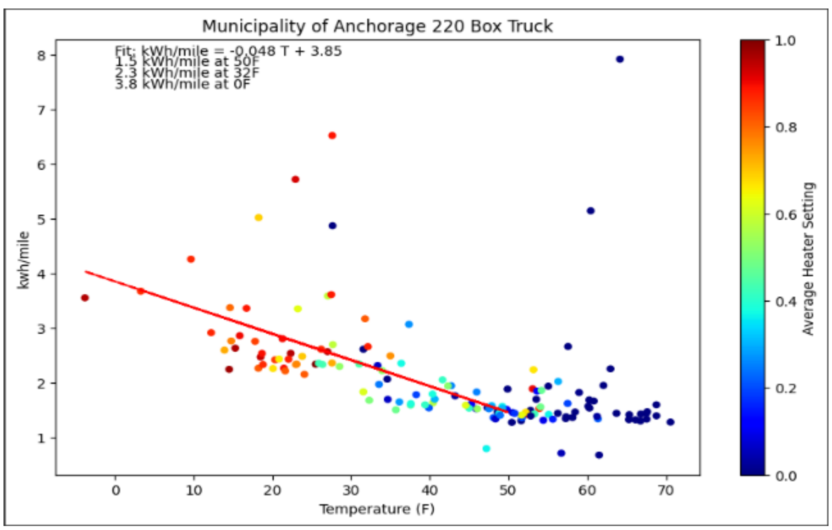

Figure I.21.5 Plot of energy consumption(kWh/mile) vs. ambient temperature (F). Linear fit line for temperatures below 50F. Temperature data was sourced from hourly temperature data at Merrill Field from www.NOAA.gov. Charging data was used to find energy consumption, downloaded from Chargepoint MOA account. Trip data to find miles traveled from Dana. Data ranges from 06-18-2021 - 06-30-2023. Color of data points corresponds to the average heater setting between charges.

The global COVID-19 pandemic, along with the accompanying border and factory closures, has made for long equipment lead times. Peterbilt reports that the two 520EVs should be delivered in 2023. SWS requested another no-cost extension, anticipating the 520EV arrival.

One benefit to the delivery delays is alignment with the construction of SWS's new transfer station facility. The original intent was to install the eCamion DCFC station at the current transfer station, then move it over to the new transfer station across the street. A local contractor installed the eCamion station at the new Central Transfer Station in November 2022. The cabinet was installed outside of the warm storage and two ports were installed inside where the two 520EV trucks will be parked when they arrive. Testing will begin when the two 520EVs have arrived. eCamion has offered to return for training, if necessary, although most of the operations can be monitored and conducted remotely from their headquarters in Canada.

Conclusion

While portions of the pilot project continued to be delayed into 2023, SWS has been working diligently to incorporate the battery, charging stations, and EV trucks into the design of the new Central Transfer Station as well as increase quality of data and analysis. This project has further encouraged SWS to go above and beyond in future-proofing the new site by laying conduit pathways to five bays from the eCamion battery, though only two will be operational with the battery per this project. Investigations are ongoing to determine safety and operational aspects of the EVSE. Currently, the indoor charging equipment as well as the DCFC are inoperable. The winter snowfall caused service delays not only for the 220EV but the entire fleet; however, the lower profile of the 220EV box truck resulted in delays that were a bit longer, as snow crews worked to clear all roads. Extensive efforts to monitor and analyze the performance of the 220EV truck have proven to aid in gleaning insights to the truck's performance and capabilities.

While the Peterbilt 220EV has come with its challenges, we continue to learn more about EV operations and will continue tracking progress and anxiously await the 520EVs. SWS remains excited about incorporating the two Peterbilt 520EVs into its fleet in 2024.

I.22 Zero Emission Freight Future (Clean Fuels Ohio)

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Start Date: October 1, 2020 End Date: December 31, 2024
Project Funding: $1,736,859 DOE share: $868,325 Non-DOE share: $868,534

Project Introduction

Clean Fuels Ohio (CFO) is partnering with Original Equipment Manufacturers (OEMs) and electric vehicle supply equipment (EVSE) providers to operate three demonstration projects of medium-duty (MD) and heavy-duty (HD) electric vehicles (EVs) in Ohio with a goal of spurring Class 4-8 EV adoption in fleet applications nationwide. MD and HD EVs are just beginning to see mass market introduction by the traditional commercial truck OEMs, with a range of OEMs beginning to release EVs in the sizes and model types that are the workhorses of commercial fleets nationwide. While aftermarket conversions have been available for some time, fleets have been waiting for OEM models as a key tipping point in the MD and HD EV adoption curve. While these OEM models are newly becoming available, many fleet questions remain about the real world operational and economic viability of these MD and HD EVs. The scope of the Zero Emission Freight Future project is to conduct small, targeted proof-of-concept demonstrations of MD/HD EVs and EVSE that can give fleets the experience needed to make technology adoption decisions, helping them understand cost, operational issues, and performance attributes before making a significant investment.

Objectives

The Zero Emission Freight Future (ZEFF) project is designed to demonstrate the viability of MD/HD EVs in new fleets, communities, or areas that have little or no experience with these technologies. The fleet and OEM project partners include highly visible fleets in freight/goods movement and refuse services, including Bimbo Bakeries and Motiv Power Systems (Class 6 EV in bakery delivery operations) and PITT OHIO and Volvo (Class 7 HD EV Straight Truck in Midwest logistics operations). The City of Columbus and Lion Electric (Class 8 electric refuse truck in city refuse operations), which were originally the third fleet demonstration and OEM partners, backed out of the project due to significant vehicle delivery delays. As a result of the removal of a third fleet demonstration partner, the project will identify additional sources of MD/HD EV performance, operations, and telemetry data from its network of local/regional partners and stakeholders to make up for the gap of EV refuse truck data. The project data modeling and analysis partner is Sawatch Labs. Through diverse partnerships, the project will employ commercially available EVs, EVSE, facilities, and app-platforms to ensure technology deployment and showcase significant return on investment.

Approach

This project will prove the operational and financial effectiveness of MD and HD EVs in commercial fleets through activities in four major areas:

1. **MD/HD EV pilots in a diverse collection of fields and industries**, with highly visible fleets in freight/goods movement: Bimbo Bakeries and PITT OHIO

2. **Updated MD/HD EV operational and economic analysis models:** Integration of MD/HD EVs in Sawatch Labs' EZ EV analysis platform with data input and detailed feedback from EV OEMs.

3. **Operational and financial MD/HD EV performance analysis tools** informed by OEM end-user data on real world vehicle deployments.

4. **Distribution of Replication Playbook** to fleet stakeholders with similar vehicle operations including sharing case studies and performing individualized analyses. The project team will use these results to demonstrate how pilot vehicles can be adopted by additional fleets to improve economic and environmental performance.

Results

CFO, in conjunction with project partners, made progress on the following milestones in the third year of the project which will continue into 2024 to wrap up project efforts:

1. Medium-/Heavy-Duty EV Deployments

2. Data Gathering and Collection

3. Telematics Data Gaps Identified and Analysis Improved

4. Analysis and Modeling Data Gathered

Medium-/Heavy-Duty EV Deployments

The PITT OHIO Volvo Class 7 VNR EV straight truck (Figure I.22.1) was delivered and deployed in May 2022 to PITT OHIO's fleet facility in Cleveland, OH. The timely arrival of the vehicle from the OEM partner will give the project excellent vehicle telemetry/operating data (~18 months) and driver testimonials by the end of 2023. The Bimbo Bakeries Motiv Power Systems EV delivery step van (Figure I.22.2) was delivered and deployed in June 2023 to Bimbo Bakeries fleet facility in Dayton, OH. The arrival of the vehicle from the OEM partner will give the project sufficient vehicle operating and driver testimonials by the end of 2023 (~6 months). The project team did not install a telemetry device in the EV delivery step van to collect any significant data in 2023; this will occur in 2024. The City of Columbus and Lion Electric (Class 8 electric refuse truck in city refuse operations), which were originally the third fleet demonstration and OEM partners, backed out of the project due to significant vehicle delivery delays.

Figure I.22.1 PITT OHIO Class 7 Volvo EV Straight Truck in Cleveland, OH

Figure I.22.2 Bimbo Bakeries Class 6 Motiv Power Systems EV Delivery Van in Dayton, OH

Data Gathering and Collection

CFO's collection of vehicle telemetry, operations, and performance data will consist of the following:

- EV data from the project's two signature vehicle demonstrations, PITT OHIO Class 7 EV straight truck in Cleveland, OH and Bimbo Bakeries Class 6 EV delivery step van in Dayton, OH
- Additional EV and non-EV (typically gasoline or diesel) data from other national MD/HD OEM data partners across various vehicle types/applications (refuse, delivery, freight/logistics, shuttle/transport, etc.) comprising Clean Fuels Ohio stakeholders, members, industry peers, and project fleet partners.

CFO asked the project's vehicle demonstration OEM partners to provide letters of commitment citing how much data (number of vehicles and number of historic data months) they will provide. These data sharing commitments entail high-level telemetry data with vehicle operational performance as well as the OEM partners' experience on their respective vehicle deployments to date, to spur the development of the Sawatch Labs MD/HD EV analysis tool. CFO plans to engage with the two OEMs, two fleet partners, and Sawatch Labs throughout Budget Period 3 to capture sufficient data. CFO facilitated communication between Sawatch Labs and several EV OEMs throughout 2023 and has provided relevant Geotab Passenger Identifications (PIDs) for their EV integration. To the extent the PIDs are available in the Geotab DataStream, Sawatch Labs is prepared to surface them in their data layer and analytics visualizations.

Sawatch Labs developed an initial list of data points and targeted areas of interest for MD/HD EV applications specific to the project (straight truck and delivery step van) to inform the data analysis on the Sawatch MD/HD "ezEV" telematics analysis platform. As part of Sawatch Labs' deliverables to create new models in their candidates table for the new MD/HD EVs and create comparable internal combustion engine (ICE) models for the project's EV applications, Sawatch provided CFO the following list of preliminary data points they would need from OEMs. Sawatch realizes that some data is proprietary and may be more difficult to retrieve. The full vehicle model data requirements requested by Sawatch include:

- Gross Vehicle Weight Rating (GVWR)
- Curb Weight
- Battery Capacity
- Estimated Range (Optional)

- Estimated Manufacturer's Suggested Retail Price (MSRP)
- Motor Count
- Motor kW Draw
- Accessory Equipment Draw

Telematics Data Gaps Identified and Analysis Improved

CFO worked with the key fleet and OEM demonstration partners and Sawatch Labs to collect and assess the telemetry data from the one deployed vehicle and determine where the gaps are in the datasets to ensure alignment with Sawatch Labs' list of target data points. Sawatch Labs utilized their existing "ezEV" suitability tool for light-duty vehicles to develop a beta version of a MD/HD EV modeling and analysis tool with the project's MD/HD EV applications. From the first 60-90 days of collected data from PITT Ohio, Sawatch Labs provided telematics data analysis improvements from their experience with conducting analysis of EV data and providing insights/dashboards of the analysis.

PITT OHIO deployed their Class 7 EV straight truck from Volvo in May 2022 which gave the project sufficient amounts of data to conduct further analysis of the vehicle operations and performance. PITT OHIO is operating two Volvo Class 7 VNR Electric Straight Trucks out of their Parma, OH facility, one in partnership with Clean Fuels Ohio through this project and the other in partnership with Drive Clean Indiana through 2021 Diesel Emissions Reduction Act (DERA) funding. Sawatch Labs conducted detailed analysis of the PITT OHIO Volvo Class 7 VNR Electric Straight Truck datasets which comes through an installed Geotab telemetry device in the truck.

Bimbo Bakeries deployed their Class 6 EV delivery step van from Motiv Power Systems in June 2023 which has not yet given the project sufficient data to conduct initial analysis of the vehicle operations and performance. The project team plans to install a Geotab telemetry device in the vehicle to start collecting and analyzing sufficient data in 2024. This is the first all-electric vehicle that Bimbo Bakeries is operating in Ohio and in the Midwest region. The insight of the vehicle user experience so far provided by Bimbo Bakeries, Corporate Fleet Manager, Eric McCann is summarized in the bullet point quotations below.

- "Bimbo Bakeries has two years in the electric vehicle space and so we are feeling good about this new EV delivery step van from Motiv Power Systems in Dayton, Ohio."
- "The van has been running very well and driver feedback has been extremely positive. We ran into an issue with one of the charge nozzles failing, but that was quickly corrected by our charging infrastructure provider. The winter testing seems to be going good for the state of charge at the end of the day; we are still in some fact finding there."
- "The van has been charging at 9.6 kilowatt hours and runs only 30 miles per day allowing us to charge the van two days a week: Wednesdays, and Sundays. The vans lose 38% of juice in the winter and so we are planning out 4-5 years of infrastructure starting next year to prepare for the future of charging our electrified fleet."

Analysis and Modeling Data Gathered

The project team seeks to capture complete project demonstration vehicle telemetry data once Bimbo Bakeries and Sawatch Labs collect data after the Geotab telemetry device is installed going into 2024. CFO anticipates Sawatch Labs completing analysis and modeling in Q2 2024 and identifying telemetry analysis needs and improvements from Bimbo Bakeries during the 2-3 months (April-June 2024) after the telemetry device is installed. Complete sufficient data collection and data gap identification for the two fleet demonstration partners should occur by June 30, 2024. Since the departure of the project's third fleet demonstration partner

(City of Columbus EV Refuse Truck) delaying successful accomplishment of original project deliverables, CFO revised minor details to the project's scope to make up for the gap of vehicle data.

CFO also identified additional sources of MD/HD EV performance, operations, and telemetry data from its network of local partners and stakeholders. CFO engaged with fleets, OEMs, and industry peers (associations, councils/committees, and other working groups focused on MD/HD vehicle applications such as refuse, transit, freight/logistics, delivery, etc.) and identified potential partners to recruit to collect MD/HD EV data. While there will not be a third fleet vehicle demonstration partner, the project will still ensure the development of a robust replication playbook with insight from at least three different MD/HD EV applications.

Conclusions

The project team is largely proceeding as planned with project plans and deliverables for the rest of Budget Period 3 and anticipates continuing into Budget Period 3 in 2024. The departure of the City of Columbus EV Refuse Truck from the project, creating a lack of real-world vehicle data for this vehicle type/application, is the biggest factor affecting the project to date. PITT OHIO and Bimbo Bakeries have both deployed their desired MD/HD EVs and have been the "key success" so far for the project. CFO has made significant strides towards data collection and detailed analysis and modeling for the Class 7 EV Straight Truck application and looks to replicate this with the Class 6 EV Delivery Step Van application in 2024. These successes will inform the project with the comprehensive feedback and technical insight from deployed, real-world MD/HD EVs in Ohio commercial fleets that CFO will use to develop replication resources, playbook, and testimonials for dissemination across the transportation industry.

I.23 Demonstrating Electric Shuttles for the New Orleans Region (Tulane University)

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Start Date: October 1, 2020 End Date: December 31, 2023
Project Funding: $1,566,510 DOE share: $737,555 Non-DOE share: $828,955

Project Introduction

Accelerating the adoption of electric vehicles (EVs) in the New Orleans region will realize both immediate public health improvements in air quality and quality of life, and long-term reductions in greenhouse gas emissions. This project at Tulane University (Tulane), a private research university in New Orleans, Louisiana, seeks to address those problems.

Tulane has long recognized the need to mitigate climate change by reducing greenhouse gas emissions. In 2008, Tulane joined the Presidents' Climate Leadership Commitment, a pledge to measure the impact of university operations on climate change and develop a strategy to reduce the university's carbon footprint. In 2015 Tulane adopted a climate action plan with the goal of realizing a 30% emission reduction by 2025 and achieving carbon neutrality by 2050. Switching to EVs is a key step in reaching carbon neutrality, as it moves fleet vehicles from fossil fuels to electricity that is increasingly sourced from clean and renewable sources.

In 2020, this project proposed to replace five diesel buses near the end of their service life with five new all-electric shuttles designed for the medium-duty bus market. Tulane operates the diesel vehicles on shuttle routes between the university's Uptown, Downtown, Elmwood and University Square campuses, and other destinations around the Greater New Orleans metropolitan area.

The proposal was developed with the Grande West Vicinity LT-E electric shuttle bus as the replacement vehicle for the medium-duty diesel buses. Early in 2022, the project pivoted to four electric conversion models when the Grande West Vicinity LT-E was found to be unavailable at the price points and timelines initially understood.

At the close of FY2022, the EV Charging Station developed for the original five vehicles had been completed and the team awaited the delivery of four medium-duty electric vehicles from Lightning eMotors early in 2023.

The charging infrastructure designed and constructed provides five fast chargers and charging bays suited to five medium-duty electric vehicles. The charging equipment installed is the ABB Terra 54 UL 50 kW DC fast charging station.

Shortly into 2023, the four electric shuttles ordered from Lightning eMotors became unavailable due to disruption in the supply chain for their batteries. At that time, the team determined satisfactory electric vehicles in the medium-duty category were not available in a timeframe acceptable to the Shuttles and Transportation department. Tulane pivoted to bring a larger quantity of smaller electric vehicles into the fleet. This decision has played out well. By the end of September 2023, the new fleet of nine electric Ford e-Transit vehicles was an integral part of shuttles operations and campus life.

Outreach for the project has begun and the research component, applying a lifecycle cost analysis to the transition to electric vehicles, has adjusted to this new approach. This project aims to provide fleet operators in our region with a local example of the viability and value of all-electric vehicles, sharing locally based information on EV infrastructure development and EV operation and maintenance costs. These later steps of outreach and research are underway. A request for no-cost continuation into 2024 to complete research and outreach is in development.

Objectives

The objective of this project is to demonstrate 1) an alternative fuel or advanced technology fleet and 2) supporting infrastructure in a region that has no or little experience with these technologies. Specifically, this project will:

- Test, document, and demonstrate the operational effectiveness of incorporating all-electric vehicles into a shuttle bus fleet in Southeast Louisiana.
- Pilot the development of a fleet charging infrastructure, to provide a model for utilities, fleet managers and contractors in our region.
- Develop a financial analysis of the lifetime costs of incorporating EV shuttle buses into the fleet that includes a carbon price, to evaluate environmental impact.
- Share experience with fleet managers in our region, both at events and at on-site workshops.

Approach

The project has been a collaboration of Tulane’s Office of Sustainability and the Shuttles and Transportation Office (both of which are part of the university’s Campus Services division) and the ByWater Institute, Tulane’s interdisciplinary environmental research center, with assistance from external collaborators Model 1 (formerly Creative Bus Sales), the university’s bus provider; our utility, Entergy; and the Southeast Louisiana Clean Fuels Partnership (SLCFP), our local Clean Cities coalition housed at the New Orleans Regional Planning Commission.

Working with an internal team and a wider group of partners, the project assessed assets available to Tulane to support a transition to electric vehicles in the Shuttles and Transportation program with the operational goal of maintaining the same level of service to the campus community. Tulane recognized the opportunity to retire five aging medium-duty diesel buses as an entry point to bringing electric vehicles into the fleet. Project partners developed plans in 2020 to address procurement, infrastructure, research, and outreach to give the Shuttles and Transportation team the experience and resources to move the Tulane transportation fleet into electric vehicles over the following three years.

Approach Pivot

The plans developed in 2020 have moved relatively smoothly, aside from vehicle procurement. The 2020 proposal targeted replacing five medium-duty Glaval Apollo diesel engine buses in the Shuttles and Transportation fleet with an equal number of medium-duty all-electric Grande West Vicinity LT-E electric buses to meet the same service needs with electric vehicles rather than diesel vehicles. However, the medium-duty all-electric buses selected were discovered to be unavailable within the budget and timeframe of the project and fleet needs. The project team launched a second procurement process for medium-duty electric vehicles in 2022 and that fell through early in 2023, again due to supply chain issues.

Facing the third procurement process, the Shuttles and Transportation team pivoted from replacing five medium-duty diesel vehicles with comparable electric vehicles to incorporating a greater number of smaller electric vehicles into the fleet. The smaller electric vehicles selected, Ford e-Transits, replaced rented Toyota Siennas, Dodge Caravans, and Chrysler Pacificas used principally to support service-learning programs.

The new electric fleet vehicles are estimated to reduce carbon emissions by 33% versus the conventional engine rented vehicles they have displaced. As is true of electric vehicle technology of any size, the new electric vehicles contribute no tailpipe emissions to local air quality concerns.

Results

In 2023, the team procured nine Ford e-Transit vehicles to shuttle students to their service-learning commitments with over 600 partners across the city, traveling along narrow neighborhood streets as well as prominent corridors. Making these trips to community partners in vehicles contributing no tailpipe emissions to local air quality is a significant and a welcome result of the final pivot in the procurement process. Figure I.23.1 shows one of the branded Ford e-Transit vehicles in the fleet charging at a completed charging bay in Tulane's Claiborne lot.

Figure I.23.1 Tulane electric shuttle charging at charging station. August 2023. Jordan Stewart Photographer.

The electric shuttles have also been deployed in an unexpected but well received and highly visible way: shuttling fans to and from auxiliary parking areas during football games and large events. Figure I.23.2 shows Shuttles & Transportation Director, Brian Lowe, with a line of electric shuttles staged to return fans to remote parking areas. Lastly, when feasible at times of low ridership on fixed routes, the smaller Ford e-Transits are deployed in place of the five aging medium-duty diesel Glaval Apollos. However, because their larger size is suited to peak ridership demands, currently, Shuttles & Transportation is not able to fully retire these medium-duty diesel vehicles. In all, the program has been highly visible and well received in the New Orleans area.

Figure I.23.2 Director of Shuttles and Transportation, Brian Lowe, with Tulane electric shuttles lined up for service during the September 9, 2023, football game. Jordan Stewart Photographer.

Key steps forward in 2023 include:

- Arrival of the electric vehicles: The nine EV shuttles arrived on campus in June and July of 2023. By September 30, the vehicles were each fully branded, linked to the telematics data collection software, and in operation daily with drivers trained on the new electric vehicles. In September 2023, the Tulane Shuttles and Transportation fleet included 23 vehicles owned and operated by the university. Nine of those vehicles are the Ford e-Transit models purchased through this grant. The remaining 14 vehicles use internal combustion engines, six of which are the medium-duty diesel engine Glaval Apollos. Based on their positive experience with the new e-Ford Transits in the fleet, the Tulane team will work toward replacing the medium-duty diesel vehicles with all-electric models of similar size when feasible.

- Adaptation of research plan: The research team is developing data collection procedures to assess this new, more complex, incorporation of electric vehicles into the fleet with lifecycle analysis that includes a carbon price.

- Launch of outreach: Tulane team members Jordan Stewart and Brian Lowe shared the project informally during a Southeast Louisiana Clean Fuel Partnership EV Roundtable held in-person January 19, 2023. The content included the project progress and procurement process to-date. Attending organizations included the Port of New Orleans and a major regional hospital. Brian Lowe, Phil Odom, and Jordan Stewart from Tulane, together with the project's utility representative, Scott Barrios, made the first public presentation of the project in April of 2023 to the Clean Fuels Conference in Baton Rouge, Louisiana. South Louisiana Clean Fuel Partnership director and project partner, Aspen Nero, facilitated the panel. The presentation focused on charging infrastructure, touching briefly on the development of the project and the procurement process.

- Website launch: Tulane launched the electric shuttles program website in September 2023. The website is available at the following address: https://shuttles.tulane.edu/electric-vehicles

- Program photoshoot: On September 27, 2023, Tulane organized a photoshoot featuring one of the electric shuttles on Tulane's campus with representatives from the project team. Figure I.23.3 is one of the group portraits taken during the photoshoot: from left to right, Scott Barrios, Entergy Electric Mobility Portfolio Manager; Deanna Rodriguez, Entergy New Orleans CEO; Patrick Norton, Tulane University Chief Operating Officer; Brian Lowe, Director of Shuttles and Transportation; Jordan

Stewart, Office of Sustainability. An article announcing the program is on deck for publication through Tulane media streams.

- Recognition in campus media: *The Hullabaloo*, the primary Tulane University student newspaper published an article written by student Patrick Johnson titled, "New Electric Shuttles Demonstrate Tulane's Commitment to Net-zero," featuring the new electric fleet on September 13, 2023.

Figure I.23.3 Photoshoot portrait of key project partners with an electric shuttle on Tulane's uptown campus. September 27, 2023. Sabree Hill Photographer.

Conclusions

The Tulane Shuttles and Transportation team has only positive reflections on incorporating the electric vehicles into the fleet. Operational experience with the five fast chargers designed for the original procurement selection paired with the nine-vehicle electric fleet has thus far created an appreciation for the speed of the fast chargers and the potential to incorporate medium-duty electric vehicles in the future.

The project team has enjoyed initial outreach efforts and looks forward to more events and future analysis as data from operations accrues.

Turning attention briefly to anecdotal observations of introducing the electric shuttles on campus, the campus community has been excited to witness and participate in an exciting step forward in the university's operations. Students and members of the broader community are curious about the new shuttles and excited to use them. Their arrival has sparked more inquiries regarding increased electric charging on Tulane's campuses.

Key Publications

The electric shuttles program website has been launched in September. The website is available at the following address: https://shuttles.tulane.edu/electric-vehicles
Patrick Johnson, "New Electric Shuttles Demonstrate Tulane's Commitment to Net-zero," *The Hullabaloo*, September 13, 2023, written by Patrick Johnson. https://tulanehullabaloo.com/63895/uncategorized/new-electric-shuttles-demonstrate-tulanes-commitment-to-net-zero/

Acknowledgements

We wish to thank our DOE Project Manager Neil Kirschner for his helpful guidance and encouragement.

The Tulane Electric Shuttles Project Team includes Tulane staff members Brian Lowe and Laura Persich. Scott Barrios of the Electric Mobility unit of KeyString Labs by Entergy remains a key team member. The Project Team also includes Kevin Grubbs from Creative Bus Sales (formerly Alliance Bus Group). Aspen Nero has taken leadership of the Southeast Louisiana Clean Fuels Partnership, member of the Clean Cities

Coalition Network, formerly led by Courtney Young. Her work is central to our regional outreach efforts. Mark Bacques, Lead Sr. Engineering Associate, Entergy New Orleans, handled the provision of electrical service.

Amanda Rivera, University Architect, Amber Beezley, Director of Feasibility, Planning and Programming, and Mark LeBlanc, Construction Project Manager, continued to provide key assistance with the design and construction of the EV Charging Station area. Melinda Viles, Creative Director, created the bus wrap design. Customer service and communications colleagues Kelly Venable Caroll, Kate Simon, and Jaime Dunkle are integral to outreach initiatives on campus and beyond. We also extend our appreciation to Viet Tran, the university's customer service contact for Entergy New Orleans who has an increasingly visible role with outreach initiatives.

I.24 Advancing Climate and Innovation Goals of Memphis and Shelby County: Electrification of Key Fleet Vehicles to Capture Cost Savings and Climate Benefits (Shelby County Government)

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Start Date: October 1, 2020 End Date: March 31, 2025
Project Funding: $1,004,024 DOE share: $500,000 Non-DOE share: $504,024

Project Introduction

The Memphis Area Climate Action Plan, a strategic framework for reducing the area's carbon footprint, calls for a shift to low-carbon transportation modes and an overall greenhouse gas emissions reduction of 51% by 2035 [1]. The plan reports that on-road transportation produced 39% of Shelby County's greenhouse gas emissions in 2016, making on-road transportation the largest contributor of emissions. As emissions per person continue to rise in Shelby County, Shelby County Government can play a significant role in improving local air quality and reducing greenhouse gas emissions. This project, focused on local government fleet electrification, is an initial step towards accomplishing the goals of the plan. The project team consists of Leigh Huffman, Robin Richardson, and Jared Darby from the Memphis & Shelby County Office of Sustainability and Resilience; and Darren Sanders, James Crook, Charles Wood, and Danny Daniels from the Shelby County Roads, Bridges, and Engineering Department (RBE).

Objectives

The objective of the project is to provide a small-scale pilot project for electric vehicle (EV) fleet adoption by Shelby County. The focus of this project is the installation of charging infrastructure, along with the acquisition of a limited number of EVs. Piloting a small number of EVs and installing charging infrastructure will help provide proof of concept for the future expansion of electric vehicles in the County fleet.

Approach

The project team will purchase five new electric vehicles – either original equipment manufacturer (OEM) factory-produced or conventional vehicles that are converted by OEM-authorized/warranted Qualified Vehicle Modifiers – that will be used by Shelby County's RBE Department. In addition, vehicle charging infrastructure will be installed in appropriate fleet parking areas to support these new vehicles, as well as future electric fleet vehicles. The project team will also ensure successful vehicle and charging equipment integration into fleet practices and duties by using a portion of requested funds to implement appropriate maintenance and operations training for key fleet services staff. Finally, the project team will analyze and evaluate vehicle performance and associated cost savings and greenhouse gas emissions reductions to better understand the impact and return on investment of this project.

Critical success factors include efficient and effective project management; regular and productive communication among project partners; comprehensive research on the specific EVs and charging infrastructure to be purchased and installed that takes into consideration employee needs, fleet management processes, and effective use of data; and robust data analysis on the impact and effectiveness of the pilot project.

Results

The project team was able to make strides in procurement and acquisition of electric vehicles and supporting infrastructure during the third year of the project. The Lion6 truck was delivered in November 2022, and RBE has been able to begin using the truck as part of the County's tire pick-up program. There have been some challenges with retention of staff who are able to drive the Lion6, which has affected its ability to be effectively driven and tested in real-world conditions, but RBE has been working on finding new CDL-certified drivers for the truck.

Three sets of charging stations have been installed over the course of the year. Path Company installed two DC Fast Chargers, both of which were manufactured by Blink Charging, at the Memphis-Shelby County Code Enforcement Building. Additionally, EJO Ventures installed one Level 2 charger in the parking garage at the County Administration Building downtown. This charging station was manufactured by Clipper Creek. All three charging stations were installed using the standard Shelby County procurement process. Additional stations will be installed at the renovated RBE building, and construction began on that project this year.

During the third year of the project, the project team:

- Received the medium-duty Lion6 truck in November 2022. See Figure I.24.1.
- Installed two DC Fast charging stations at the Memphis-Shelby County Code Enforcement building.
- Started collecting data on how the Lion6 truck performed in real-world conditions, tracking variables like temperature, mileage, and level of charge.
- Conducted several maintenance training sessions for the Lion6 truck, ensuring the team would be able to service the vehicle correctly and safely.
- Installed one Level 2 charger at the Vasco A. Smith Jr. County Administration Building at 160 N. Main St. See Figure I.24.2.
- Started construction on the renovation of the Roads, Bridges, and Engineering building, which will include the installation of additional charging stations, with an expected completion during the first quarter of 2024.

The team has also identified a potential area of improvement for the Lion6 truck. Due to the current configuration of the truck as a flatbed truck, it is difficult for workers to haul tires on and off the truck bed due to the weight of the tires and the height of the bed. RBE staff have recommended getting a liftgate to add to the back of the truck, which would make loading tires much easier. The team sent specifications to area vendors at the end of September and hopes to identify a vendor who can install this liftgate shortly thereafter.

Figure I.24.1 RBE staff attends a training session on how to use the Lion6 truck. Source: Memphis-Shelby County Division of Planning and Development.

Figure I.24.2 A Chevrolet Bolt EUV owned by the Shelby County Department of Housing charges at the new Level 2 charging station installed at the Vasco A. Smith County Administration Building. Source: Memphis-Shelby County Division of Planning and Development.

Conclusions

The project has continued to build momentum over the past year, as we have received and begun to use the Lion6 truck and have installed additional charging stations. We eagerly await the arrival of the previously ordered Ford F-150 Lightnings, which we expect to receive in the final months of 2023. We also plan to install a liftgate on the Lion6 truck in early 2024 to enhance its functionality for the tire pick-up program. Once the Lightnings are received, we will proceed to the data gathering and analysis portion of the project.

References

[1] Memphis-Shelby County Office of Sustainability and Resilience. "Memphis Area Climate Action Plan." Memphis and Shelby County Division of Planning Development, January 4, 2020. https://shelbycountytn.gov/DocumentCenter/View/37431/Memphis-Area-Climate-Action-Plan-2019-FINAL_4_JANUARY-2020.

Acknowledgements

The project team thanks Jonathan Overly of East Tennessee Clean Fuels Coalition for his invaluable assistance and guidance on this project. The team is also grateful for the work conducted by Dana Sjostrom and Vivian Ekstrom by applying for the grant and conducting initial research.

I.25 Medium-duty Electric Truck (eTruck): Pilot Electrified Fleets in Urban and Regional Applications

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Start Date: October 1, 2020 End Date: December 31, 2024
Project Funding: $2,000,153 DOE share: $1,000,000 Non-DOE share: $1,000,153

Project Introduction

The successes of trucking fleets rely on the capabilities of adapting to new technologies. Compared to conventional trucks, battery-electric trucks (eTrucks) have potential advantages in reducing fuel and maintenance costs as well as harmful greenhouse gas emissions. The Medium-duty (MD) truck market is a likely candidate for a significant and near-term adoption of eTrucks in daily, return-to-base, urban and regional trucking applications of fewer than 100 miles per day. However, many trucking fleets have very limited or no exposure to the new eTruck technology. The lack of eTruck experience and the concerns about eTrucks including range limits, charging infrastructure availability, maintenance, and cost, are considered the main barriers for the broader adoption by trucking fleets of MD eTrucks. The wide range of urban and regional applications for MD trucking fleets necessitates MD eTruck demonstration data to facilitate eTruck adoptions.

The project is led by The University of Texas at Austin (UT Austin) with 14 team members. Smart Charge America leads the effort of charging station installation/removal in Texas. Lone Star Clean Fuels Alliance and Texas Trucking Association work on the outreach and trucking fleet recruitments in Texas. Tennessee Technological University (TTU) leads the work in Tennessee. Seven States Power Corporation leads the effort of charging station installation/removal in Tennessee. East Tennessee Clean Fuels Coalition, Middle-West Tennessee Clean Fuels Coalition, and Tennessee Trucking Association work on the outreach and trucking fleet recruitments in Tennessee. Lightning eMotors (LEM) and SEA Electric each provided an eTruck, and the third one was provided by XOS. UT Austin sends Oak Ridge National Laboratory (ORNL) and National Renewable Energy Laboratory (NREL) the eTruck data from the project.

Objectives

The objective of this project is to demonstrate a MD eTruck technology fleet of three eTruck vehicles and supporting infrastructure in fleets that have little or no experience with these technologies. The MD eTruck demonstration testbed is used to evaluate the performance of MD electric trucks in various applications by a diverse group of trucking fleets. The project may help potential fleets gain necessary eTruck knowledge and experience to make informed decisions about MD eTruck adoption. The project collects eTruck fleet operational and use data to analyze the challenges and needs associated with the use of MD eTrucks in fleets across a broad range of geographical locations.

Approach

To achieve the project objectives of promoting MD eTruck awareness in the trucking industry and facilitating the adoption of MD eTrucks in various trucking fleets for urban and regional applications, the planned approaches in this project include the following:

- Approach 1: Develop MD eTruck demonstration and charging infrastructure in various fleets to help fleets with limited or no eTruck experience make informed decisions on eTruck adoptions.
- Approach 2: Collect first-hand MD eTruck fleet operational data for daily return-to-base applications in Texas and Tennessee.
- Approach 3: Conduct data analysis and modeling to understand MD eTruck operations in various urban and regional fleet applications.
- Approach 4: Share information and conduct outreach to promote eTruck public awareness and educate next-generation electric vehicle engineers.

Results

The Foreign National approvals of several project team members have delayed the progress. DOE has approved a 12-month extension for budget period 1. Additionally, vehicle and equipment delays from vehicle suppliers and vehicle repairs have impacted the project progress.

The main results accomplished this year are summarized as follows:

Electric MD trucks

UT Austin has purchased and received two eTrucks and TTU has purchased and received one eTruck; a Class-4 eTruck made by LEM, a Class-5 eTruck by SEA Electric, and a step-van eTruck by XOS (Figure I.25.1) and set up data acquisition systems to collect various operational data for all three trucks. In addition to the default dataloggers provided by the manufacturers, UT Austin installed a secondary data logger for the SEA truck to meet the required data resolution. A virtual machine server is used for the logger's data transfer process. The list of available signals is matched between the trucks and the team has verified the collected data.

Figure I.25.1 Class-4 electric truck from Lightning eMotors (left), Class-5 electric truck from SEA Electric (center), and step van eTruck from XOS (right).

Fleet Recruitment and Demonstration

All documentation processes necessary for the fleet recruitment and demonstration in Texas and Tennessee are completed. The Institutional Review Board (IRB) approved the applications for the eTruck demonstration for both UT Austin and TTU, and the vehicle loan agreements and study consent forms are finalized. UT Austin has prepared recruitment materials, including an information flyer and public websites, and passed them on to Lone Star Clean Fuels Alliance, which has reached out to fleets in Texas to encourage participation from public, private and government-owned fleets with varying fleet sizes and daily mileage. UT Austin has evaluated the applications received and notified the approved fleets of their expected loan periods and relevant project details. For Tennessee, East Tennessee Clean Fuels Coalition (ETCF) has been working with TTU on fleet recruitment.

In Texas, UT Austin loaned the LEM and SEA trucks to seven different fleets in the Austin area, and the paperwork for the next fleets is in progress. UT Austin has collected data and shared it with NREL and ORNL. For each fleet, Smart Charge America conducted site inspection and installation of a Level-2 charging station.

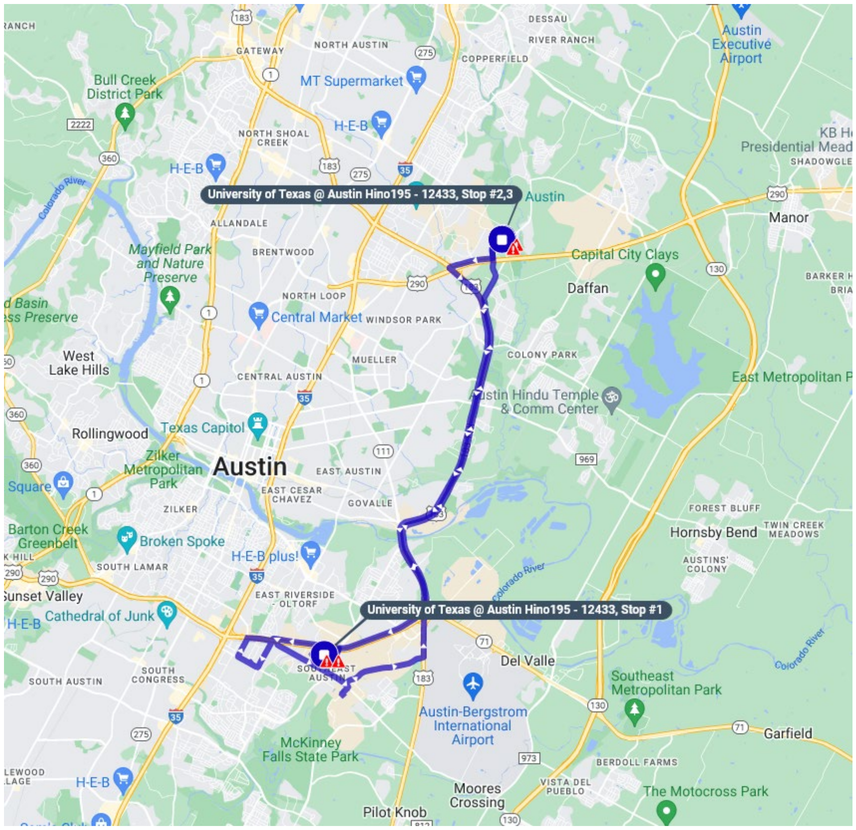

Figure I.25.2 Example of GPS coordinate of data collected from the SEA electric truck.

In Tennessee, Seven States Power Corporation has donated 16 Level-2 chargers to this project. These charging stations will be installed at the bases of potential fleet partners in the project to support electric truck charging overnight. The step van eTruck has been used by a fleet in Tennessee and is being scheduled for several other fleets to use.

Data analysis and Modeling

Before the collected data can be used for modeling, analysis or simulation, the data needs to be preprocessed. UT Austin differentiates and labels the data collected from both trucks based on the driving/idling/charging operations, with unnecessary data removed. UT Austin then consolidates all data types from multiple sources including the payload information logged manually by the drivers and a secondary datalogger for the SEA truck, into a single file. See Figure I.25.2.

Truck modeling using the processed data is in progress. With the truck specifications provided by the manufacturers, UT Austin and TTU are creating simulation models for three electric trucks using vehicle simulation tools such as Autonomie (by Argonne National Lab) and FASTsim.

UT Austin researchers collected post study surveys on the user experiences of the fleet managers and drivers. The survey is set up to be able to compare not only the participant's perception of the electric trucks before and after the study in various fields such as range satisfaction, charging and environmental impact, but also to compare experiences in fleet applications. The team is conducting additional fleet manager interviews to better understand the collected data, including information on repeated destinations, additional passengers or charging patterns.

The team has published eight peer-reviewed papers from this project.

Education and Outreach

Several efforts were made to promote eTruck public awareness in Texas and Tennessee:

- The team attended two events hosted by a partner of the team, Lone Star Clean Fuels Alliance: 'EV Readiness Roundtable Webinar - Batteries! Increasing Range & Battery Life with Holt Truck Centers & Xos Trucks on January 19, 2023 and 'Electric & Hydrogen Vehicle Workshop and Ride & Drive' on March 7, 2023. Smart Charge America, one of the project partners in Texas, presented a session on fleet charging at the workshop.

- On June 30, 2023, the Tennessee Team hosted a webinar to introduce the medium-duty electric truck project to the potential stakeholders in Tennessee and in the nation. Other partners that joined as the panel speakers included UT Austin, Thompson Truck Centers, Xos Truck, and Waller's Package Service. More than 80 people across the nation registered for the webinar with over 50 people attending to hear more about the project and borrowing the Tennessee Tech electric truck for test-drives. The webinar covered various relevant topics including the overview of the DOE project, the updates of the medium-duty electric box truck demonstration from the Texas team, introduction of medium-duty electric step van, first-hand test-drive experience provided by Thompson Truck Centers to Waller's Package Service, outreach activities and potential funding opportunities, and useful resources for the potential stakeholders.

- The TTU team participated in the Fleet Vehicles Road Show hosted by Route Consultant in Nashville, Tennessee, on April 20, 2023, to introduce the DOE-funded pilot electric truck demonstration project to the participants. This event provided fleet managers with a better understanding of the critical fleet decision-making to improve the business's profitability. Using electric trucks with lower total cost of ownership is a key.

- On April 22, 2023, the Tennessee Team including Tennessee Tech, Middle-West Tennessee Clean Fuels Coalition ETCF, and Thompson Truck Centers, joined the 2023 Nashville Earth Day Event and showcased an Xos electric step van at the event. During the event, the team directly engaged with about 150 people and the electric truck was exposed to 1500 visitors.

- The project team participated in the EV outreach event in Clarksville, Tennessee on May 11, 2023, to promote awareness of the electric step van in last-mile delivery in the city applications. Due to the challenge of delivering the vehicle from TTU to the event site, TTU sent an F150 Lightning electric pickup truck and electric SUV to the event for outreach and education, in lieu of the step van.

- ETCF arranged to have the XOS step van represented at Memphis Light, Gas and Water's Driving EV Leadership event, which was held in Memphis on May 25, 2023. Thompson Truck Centers supplied the step van from their Memphis location. The project team also partnered with FedEx to showcase a BrightDrop Zevo 600 electric delivery van.

- ETCF took on the responsibility of building a website specific to the project with plans to clearly display the three trucks' capabilities with fleet managers in mind as the individuals most likely to traffic the site. The project website can be found via the following link: https://mdetruck.com/

Conclusions

This year, the project team has made satisfactory progress, finishing most of the project milestones for this period despite the unforeseen delays. On both the Texas and Tennessee sides, the truck demonstrations have begun, with the data acquisition for three trucks fully set up and the necessary paperwork completed. Additional fleet recruitment for the three trucks is continuing.

UT Austin has loaned its two trucks to seven different fleets in Austin and has collected operational data of the trucking fleets including the vehicle maneuver, GPS, payload, and charging. The team then used the processed data to create truck models in vehicle simulation tools to be used in further studies. In addition, UT Austin conducts post-study surveys on fleet managers and drivers to collect practical user experiences with the eTrucks.

Despite the truck delivery in Tennessee having been delayed significantly, the TTU team has started the electric truck demonstration in fleets and made significant progress in the Education and Outreach area, promoting electric trucks in Tennessee by attending regional conferences and Expos.

Key Publications

Ahn, H., Zhou, X., Shen, H., Kung, Y., & Wang, J. (2023), Remaining Driving Range Estimation of Medium-Duty Electric Trucks During Delivery. *Proceedings of the 2023 IEEE International Automated Vehicle Validation Conference*, 2023.

Ahn, H., Wang, Z., Shen, H., Zhou, X., & Wang, J. (2022). A Two-Stage Genetic Algorithm for Battery Sizing and Route Optimization of Medium-Duty Electric Delivery Fleets. *IFAC-PapersOnLine*, 55(37), 50-55.

Innis, C., & Chen, P. (2022). A Fast Macroscopic Speed Planner for Electric Vehicle Platooning. *IFAC-PapersOnLine*, *55*(24), 72-77.

Su, Z., & Chen, P. (2022). Extremum Seeking Control-based Control Framework for Electric Vehicle Platooning. *IFAC-PapersOnLine,* 55(24), 123-128.

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Su, Z., & Chen, P. (2022). Cooperative Eco-driving Controller for Battery Electric Vehicle Platooning. *IFAC-PapersOnLine*, *55*(37), 205-210.

Su, Z., & Chen, P. (2022). Eco-driving for Battery Electric Vehicles Using Traffic-aware Computationally Efficient Model Predictive Control. *IFAC-PapersOnLine*, *55*(37), 700-705.

Su, Z., & Chen, P. (2022). Extremum Seeking Control-based Control Framework for Electric Vehicle Platooning. *IFAC-PapersOnLine*, 55(24), 123-128.

Acknowledgements

We acknowledge the collaboration and support from the project team members including University of Texas at Austin (UT Austin), Tennessee Technological University (TTU), Lightning eMotors (Colorado), XOS (California), SEA Electric (California), Smart Charge America (Texas), Seven States Power Corporation (Tennessee), Lone Star Clean Fuels Alliance (Texas), East Tennessee Clean Fuels Coalition (Tennessee), Middle-West Tennessee Clean Fuels Coalition (Tennessee), Texas Trucking Association (Texas), Tennessee Trucking Association (Tennessee), Oak Ridge National Laboratory (Tennessee), and National Renewable Energy Laboratory (Colorado).

I.26 WestSmartEV@Scale: Western Smart Plug-in Electric Vehicle Community Partnership (PacifiCorp)

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Start Date: October 1, 2020 End Date: December 31, 2024
Project Funding: $17,066,146 DOE share: $6,040,647 Non-DOE share: $11,025,499

Project Introduction

The *WestSmartEV@Scale* project is creating an enduring regional ecosystem across the Intermountain West to sustain accelerated growth in freight, business, and consumer use of electric vehicles (EVs). The comprehensive and ambitious community partnership project includes more than 25 strategic partners spanning 7 states and will address regional challenges in five critical EV application focus areas: destination highways, underserved regions, urban mobility, freight and port electrification, and community and workplace charging.

Over the past four years, PacifiCorp and its partners have led innovative EV infrastructure and adoption initiatives in Utah as part of the DOE funded *WestSmartEV* project. The efforts catalyzed a 400% increase in EVs in Utah from 2,500 in 2016 to approximately 12,000 in 2020. The *WestSmartEV@Scale* project will leverage lessons learned and best practices from the tremendous success of the *WestSmartEV* project in Utah. It will inject new technology and innovation to facilitate successful expansion into a regional program covering portions of Washington, Oregon, Idaho, Wyoming, Nevada, and Arizona – covering all major corridors in and out of California. The expansion encompasses coastal, mountain, desert, farmland, and forest regions with populations of over 20 million people living in communities that range from small rural and mid-size towns to large metropolitan areas. The project will cement synergy among the region’s utilities, Clean Cities programs, local towns, cities, states, businesses, and consumers.

Objectives

The objective of the project is to identify pathways to accelerate use of EVs. The pathways will be evaluated by researchers through the analysis of EV infrastructure gaps, EV workforce development training, EV infrastructure deployment and data gathering, freight and port load, and grid evaluations. The impact of WestSmartEV@Scale is to further pull together and help bring to scale the multi-state regional activities. These areas have a common public interest in executing a strategic, directed, coordinated, phased deployment of EV and charging infrastructure programs that will break down barriers to, and accelerate, EV adoption. This project aims for unified, large-scale charging and vehicle data collection on all program activities, data analysis and processing, reporting, and public dissemination, which would not occur otherwise. Communities both large and small, urban and rural, will benefit from this project’s generation of aggressive adoption activities and lessons learned.

Approach

The goals of the WestSmartEV@Scale project will be achieved through twelve synergistic, targeted, and impactful subprojects that encompass the five critical EV application focus areas of: Destination Highways, Underserved Regions, Urban Mobility, Freight (Airport/Port), and Community/Workplace. The utility partners will work together with their local Clean Cities coalitions to implement the key aspects of the subprojects within their territory. The desired outcome of the WestSmartEV@Scale project is to create an enduring regional ecosystem across the Intermountain West to sustain accelerated growth in freight, business, and consumer use of electric vehicles, as shown in Figure I.26.1.

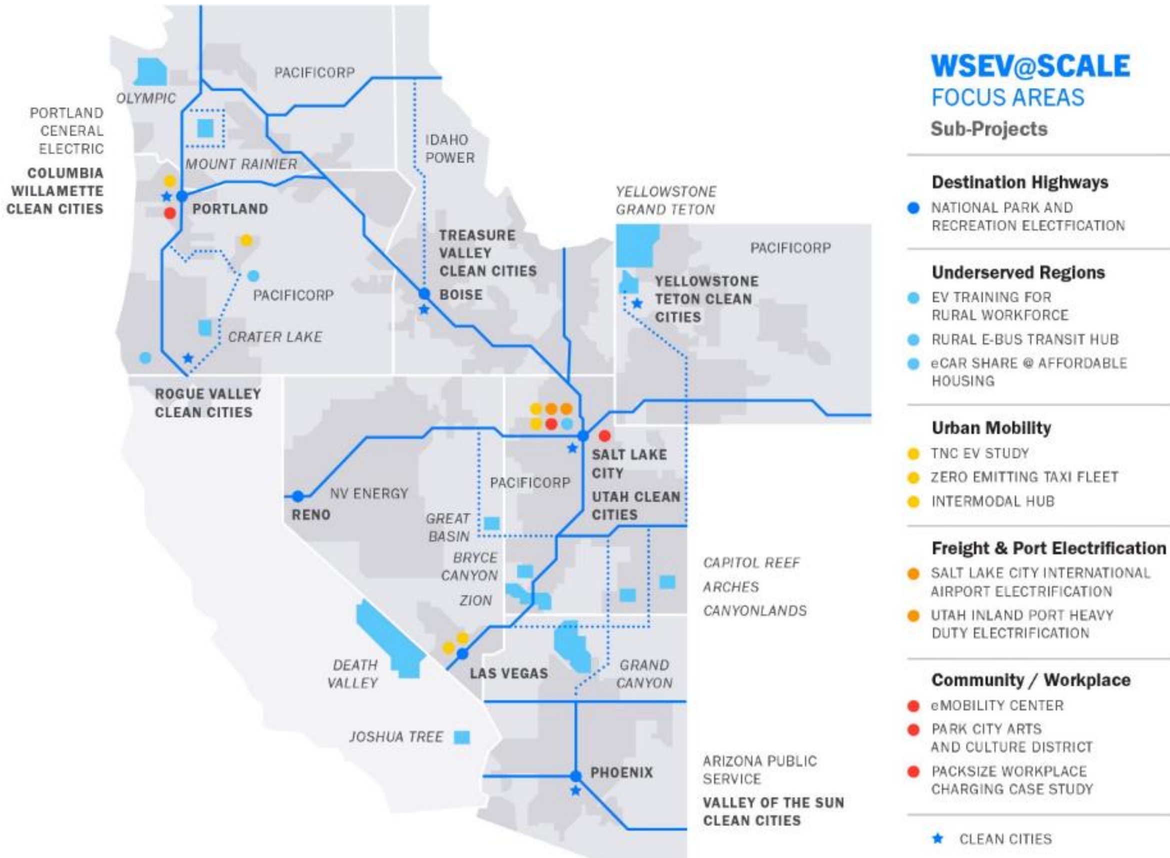

Figure I.26.1 WestSmartEV@Scale region, utility territories, and sub-project locations

The project will be administered in three annual phases:

Period 1: Modeling, Planning, and Design: The project team will conduct subproject level modeling, planning, and design.
Period 2: Implementation and Operation: For each subproject demonstration, the project team will conduct infrastructure and program implementation and operation, including data collection, partner and community engagement, and analysis and evaluation of real-world data for program performance and benefits.
Period 3: Outreach and Education: The project team will complete the evaluation of how to take programs and demonstrations to scale, supported by outreach and education across the region and broadly to the technical and public communities.
Descriptions of the subprojects are as follows:

Focus Area 1 - Destination Highways

- **National Park and Recreation Area Electrification:** Evaluate gaps in EV infrastructure to ensure access to National Parks and recreation areas in the region.

Focus Area 2 – Underserved Regions

- **EV Training for Underserved Workforce:** Evaluate EV workforce development initiatives with communities.
- **Rural eBus Transit Hub:** Develop rural transit bus hub and study effectiveness of electric buses (eBuses) in rural communities.
- **eCar Share @ affordable housing:** Develop electric car (eCar) Share program and evaluate expanding program to allow low-income residents to use the vehicles for ride hailing services.

Focus Area 3 – Urban Mobility

- **Intermodal Hub**: create a multi-megawatt, co-located, coordinated, and managed charging system at a multimodal transit center.
- Transportation Network Company (TNC) EV Study: Monitor driving and charging behavior of TNC EV drivers across multiple states.
- Zero Emitting Taxi Fleet: Evaluate the potential to effectively convert legacy taxi fleet to zero emitting vehicles.

Focus Area 4 – Port and Freight Electrification

- **Salt Lake City International Airport Electrification**: Evaluate various options for electrifying newly built airport, including the load and grid impacts.
- **Utah Inland Port Heavy Duty Electrification**: Evaluate potential to electrify newly created Inland Port using real world freight data and simulation testing.

Focus Area 5 – Community

- **eMobility:** demonstrate and study electric mobility (eMobility) options to alleviate transportation constraints in congested areas including multi-modal solutions.
- **Park City Arts and Culture District:** evaluate and demonstrate the effectiveness of an integrated location of ebuses, microtransit, and EV parking to provide solutions that reduce transportation sector emissions.
- **Workplace Charging:** Analyze workplace charging program and evaluate performance and technical requirements for smart charging at the workplace.

Results

Overall Project Results for Fiscal Year (FY) 2023:

- Developed partnership with Crater Lake Training Center to develop rural focused Electricians Pre-Apprenticeship Program in southern Oregon.
- Successfully launched On-Demand rural electric bus and installed associated infrastructure in Tooele Utah.
- Developed case study on electric taxis in the Las Vegas area.
- Analyzed the potential of deploying battery storage at co-located sites for electric buses and publicly available direct current fast charger (DCFC).
- Launched electric bus rapid transit (BRT) route at eMobility Hub in Ogden, Utah.

- Successfully held events for underserved communities to bring education and awareness of transportation electrification to those communities.

Focus Area 1 – Destination Highway Analysis: National Park and Recreation Area Electrification

- Estimated charging station network required to enable electrified road trips to/from/between/through National Parks. See Figure I.26.2.

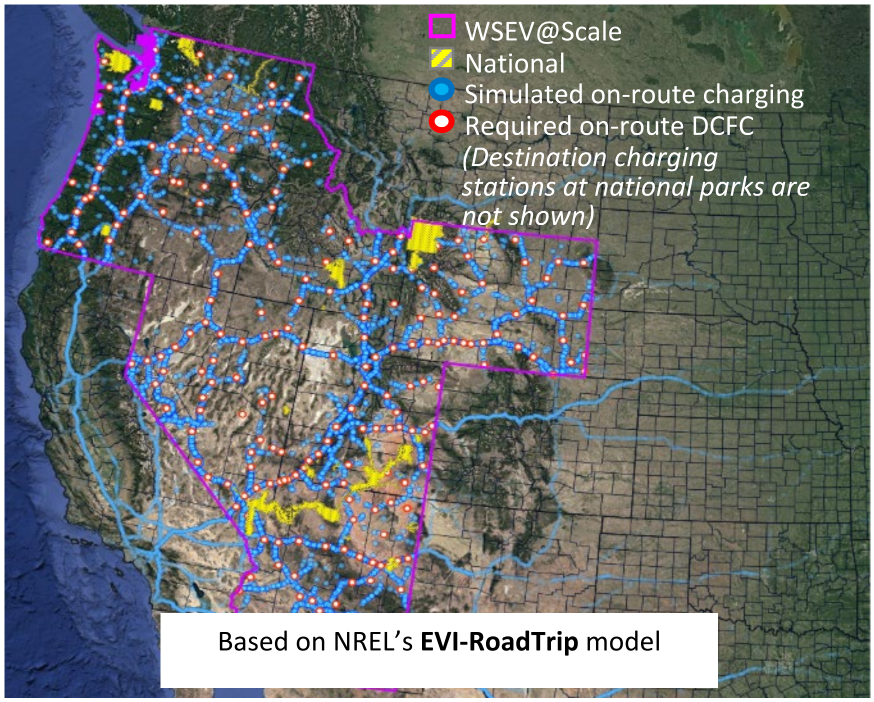

Figure I.26.2 Analysis of charging station needs for National Parks

- Conducted a survey of consumers' experiences, perceptions, barriers, and opportunities for using electric vehicles to make road trips to recreational areas and for recreational activities. Survey respondents were recruited from a study population of electric vehicle owners (including plug-in hybrid) or drivers (age 18+) with at least one qualifying road trip experience.

- As a result of the survey findings, over 20 highway corridor charging locations are undergoing planning, design, and implementation in Utah with DCFC capabilities that exceed the technical requirements outlined as part of the National Electric Vehicle Infrastructure program. Among these locations is a site close to the Arches National Park in Moab with direct access to Lions Park and Bike Path Trailhead that runs along the Colorado river and connects with multiple recreational areas. Another site includes a location along the historic Main Street in Vernal, Utah. Vernal Utah is the gateway and transportation hub for the Dinosaur National Monument located in Utah and Colorado. These highway corridor charging locations will enable drivers to visit the various National Park and Recreational areas across the state of Utah.

Focus Area 2 – Underserved Regions: Rural Workforce Development

- Partnered with Crater Lake Training Center to develop a rural focused Electricians Pre-Apprenticeship Program in southern Oregon. The training center works with the International Brotherhood of Electrical Workers and is developing a program for high school students.

- Designed a mobile education unit for rural students that utilizes electric vehicle technologies for instruction. See Figure I.26.3 for a photo of the mobile education unit being developed.

Figure I.26.3 Photo of Mobile Education Unit. (Photo courtesy of PacifiCorp)

Focus Area 3 – Urban Mobility: Intermodal Hub Study

The Intermodal Hub site in Salt Lake City features two forms of electric transportation: electric buses and electric light rail (known as TRAX). The eighteen electric buses in use by the Utah Transit Authority in Salt Lake City can charge during their stops at the Salt Lake Central station by using one of two overhead chargers, which provide high power during their short breaks at the station. The TRAX light rail is powered directly by traction power substations (TPSS) along the route. The light rail uses significant amounts of power to move, particularly when accelerating away from a stop. These two loads create major peak power demands at the site. The bus charger's power is measured using the Open Charge Point Protocol (OCPP), which communicates when and how much electrical energy was used for charging the bus during its time at the station. Similarly, the TPSS is equipped with a data logger that records the power consumption of the light rail at an interval of about ten seconds. Figure I.26.4 includes photos of the two electrical loads. The team calculated the optimal use of the bus charger and TPSS to meet the needs of the electric bus and electric light rail while reducing the impact on the local electrical grid.

Figure I.26.4 Traction Power Substation (left) and Overhead bus charger (right) (Photo: Utah Transit Authority)

Focus Area 4 – Port and Freight Electrification: Utah Inland Port Heavy Duty Electrification

- Developed electrification potential for heavy duty trucking by analyzing individual fleet trucks using telematics data with 1Hz data logger. The telematics data was taken from trucks driving routes in the greater Salt Lake City area. Figure I.26.5 contains a map of the routes analyzed along with the miles driven and gallons of fuel used.

- Using the telematics data, the team expanded previous electrification analysis of fleets operating in the Utah Inland Port area and concluded that the clear majority of trips could be electrified with current technology.

- The team analyzed the potential of sharing electrical infrastructure across a corridor of multi modal electric transportation. The different modes of transportation include commuter rail, light rail, heavy-duty freight, medium delivery, last mile delivery, bus, and passenger vehicles. The shared infrastructure could lower the overall cost and enable the acceleration of electrification particularly for medium and heavy-duty vehicles.

Parameter	Miles of Data	Gallons Used	Hours of Operation	Vehicle Days
Value	51,908	10,017	2,092	215

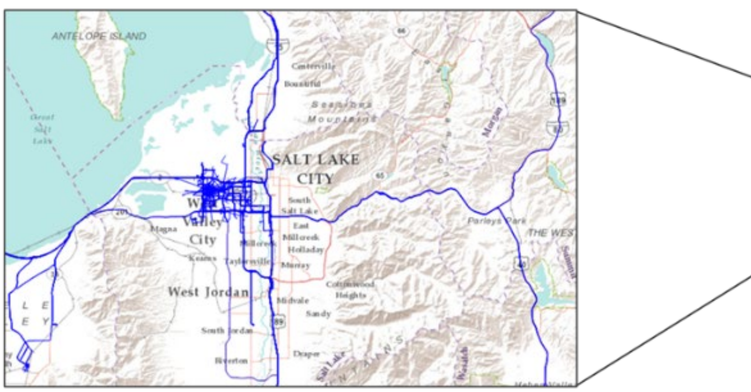

Figure I.26.5 Map of truck routes with data loggers in the greater Salt Lake City area

Focus Area 5 – Community: eMobility Hub

The project is developing an eMobility hub in Ogden, Utah that will implement multi-modal electric transportation solutions including ebuses, e-ride sharing, ebikes and scooters. The electric bus charging at the eMobility hub began operation in 2023. The electric bus uses a bus rapid transit (BRT) lane from the hub through downtown Ogden to Weber State University. The project completed design and is filing a permit to construct publicly available DCFC within the eMobility hub at the historic Union Station train station. See Figure I.26.6. The Union Station facility is a museum celebrating the golden spike, the connecting of the intercontinental railroad near Ogden Utah.

Figure I.26.6 Historic Union Station (Photo courtesy of Ogden City)

Conclusions

The project team continued to implement the key activities associated with the primary objective of the WestSmartEV@Scale project, which is to create an enduring regional ecosystem across the Intermountain West to sustain accelerated growth in freight, business, and consumer use of electric vehicles. To date, the team identified specific electric infrastructure needs at National Parks and Recreation Areas in the region. The team partnered with the Crater Lake Training Center (an International Brotherhood for Electrical Workers sponsored training facility) to develop electrician Pre-Apprenticeship programs for rural students. The team successfully launched an On-Demand rural electric bus and completed a case study evaluating electric taxis in Las Vegas, Nevada with lessons learned. Lastly, the team began operation of electric buses at the eMobility hub in Ogden Utah.

I.27 Mid-Atlantic Electrification Partnership (Virginia Department of Energy)

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Start Date: October 1, 2020 End Date: December 31, 2024
Project Funding: $14,280,850 DOE share: $5,388,154 Non-DOE share: $8,892,696

Project Introduction

The purpose of this project is to support and foster a regional electric vehicle (EV) ecosystem in Virginia, the District of Columbia (D.C.), Maryland, and West Virginia, allowing all sizes of EV use for fleets, Transportation Network Companies (TNCs), and consumers. This ecosystem project will connect the Capital Region's cities, employing multiple EV and infrastructure sub-projects, including multimodal hubs, such as airports, seaports, and logistics centers, while addressing educational, planning, and equity issues of populations near these hubs and within cities and towns. This project will support inter- and intra-city trips for commercial and government entities, consumers, ridesharing fleets serving social service centers, airports and other passenger destinations, schools, and trucks serving large distribution centers (ports), as well as EV charging for employees and visitors at these facilities. The project will develop an ecosystem of tools, education, and teams, supporting educational events with frontline communities, and piloting and strategically deploying light-, medium-, and heavy-duty EVs, while installing charging stations across the area.

Strategies to reduce the impact of air pollution are well-documented in research studies, e.g., clean air policies, and increasing access to and adoption of clean transportation options. Our work and research indicate that members of disadvantaged communities and frontline communities may not know about available opportunities or be aware of the correlation between vehicle emissions, air pollution, and public health impacts. Our effort will engage diverse community stakeholders in an authentic, culturally relevant manner, acknowledging past injustices and identifying ways we can work collaboratively to address gaps in transportation and mobility as well as explore opportunities for economic and workforce development.

Objectives

The project enables a regional EV ecosystem in Virginia, the District of Columbia, Maryland, and West Virginia, allowing all sizes of EV use for fleets, TNCs, and consumers through the creation of analysis tools, the deployment of educational activities, and the deployment and demonstration of vehicles and infrastructure.

Approach

To accomplish these project objectives across the Mid-Atlantic Region, this project has implemented a three-year, strategically phased, directed, and coordinated implementation plan. The three annual phases are below:

Budget Period 1: Project Planning, Kick-Off, and Analysis – Partners clarify existing, develop new, and create flexible pathways toward project commitments and milestones based on analysis derived from Argonne National Laboratory (Argonne) tools, and incorporate data collected.

Budget Period 2: Education, Analysis, Deployment, and Implementation - Partners reach out to stakeholders critical to achievement of project outcomes and milestones. Partners work with those critical stakeholders to implement project plans outlined in Budget Period 1.

Budget Period 3: Final Deployment, Analysis, Results, and Reporting - Partners will continue to finalize analyses conducted in earlier periods. Partners produce reports of results in various formats. Partners focus on continuing outreach to report results, share lessons learned with partners and others in the region, and explore possibilities for greater and continued impact.

Results

Commitment Review and Planning

The project team launched the Mid-Atlantic Electrification Partnership, solidified all commitments, and finalized and submitted outlines for achieving milestones.

Project Meetings

The project team maintains regular monthly meetings as well as subcommittee meetings on infrastructure, ports analysis, and education and outreach. Meeting minutes are maintained in the project files.

Educational Series

As the nation emerged from the pandemic, more in-person outreach events have taken place, with a focus on diversity and inclusion. Outreach partner EVNoire leads collaborative efforts with other project partners to educate communities. Table I.27.1 details outreach events to disadvantaged communities and historically black colleges and universities (HBCUs).

Table I.27.1 Outreach Events

Project Year	Virtual Events	In-Person Events	Total
2021	7	2	9
2022	5	11	16
2023	6	5	11
Overall	18	18	36

One HBCU outreach event of note was the Norfolk State University EV Demonstration Event held during National Drive Electric Week in September 2023, in partnership with EVNoire and Virginia Clean Cities. This student-focused event featured live radio interviews, a ride and drive, and charging station exhibitors.

Figure I.27.1 Flier for EV Demonstration Event

Other Outreach Activities

Virginia Clean Cities and the Greater Washington Region Clean Cities Coalition conducted many in-person outreach events, including in disadvantaged and rural communities. See Figure I.27.1. Various project partners including electric utilities and charging companies joined in these educational opportunities.

Site Analysis

Argonne developed the Geospatial Energy Mapper (GEM) tool which is a comprehensive online mapping tool that helps to identify areas that are suitable for low- or no-carbon power generation and other energy-related projects. See Figure I.27.2. GEM is a redesigned, reengineered, and rebranded system based on the core data and capabilities of the Energy Zones Mapping Tool. Argonne also developed a project-specific tool for the region called the Mid-Atlantic Electrification Partnership Mapping Portal.

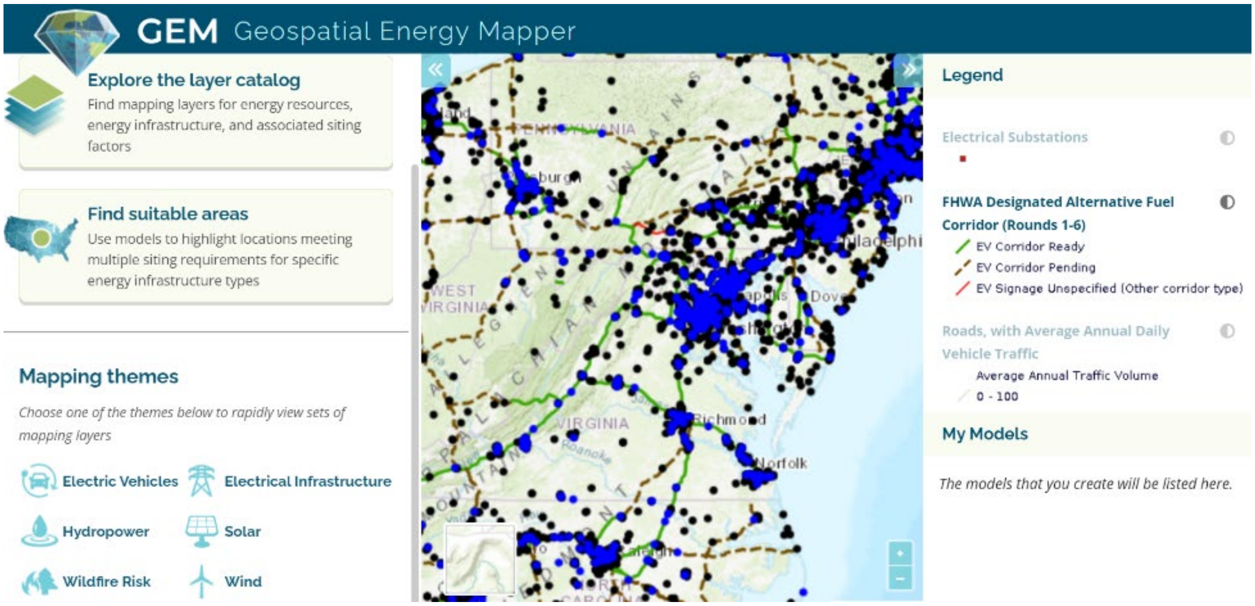

Figure I.27.2 Screenshot of the GEM Tool

Infrastructure Study, Development, and Ecosystem

The project team developed a successful EV charging station intake process and tracking system for potential host sites. The project team submitted 66 environmental questionnaires for sites through the U.S. Department of Energy's Project Management Center. This process was facilitated by DOE's categorical exclusion of EV charging stations, which has also been adopted by the U.S. Department of Transportation. The project partner deploying fast L2 charging sites on the Blink network has already identified and obligated sites equivalent to the entire 200 targeted ports for the project.

Ecosystem Mobility Hubs

The project team has held nearly 100 meetings with municipalities on EV charging deployment in the three project states and Washington, D.C. Project partner Greenspot deployed e-mobility hubs at five locations and construction plans are underway for other sites. Local government host sites have encountered procurement challenges which has slowed progress, primarily associated with desire for equipment longevity beyond five years. Hardware changes are under exploration for the final project year.

Solar Charger Demonstrations

James Madison University and Eastern West Virginia Regional Airport deployed solar EV charging stations. Both institutions continue to educate members of the public about the off-the-grid charging technology through public events.

Electric School Buses and Charging

The project team launched electric school bus efforts with the selection of Frederick and Montgomery Counties in Maryland, which are some of the nation's largest electric school bus deployments. Project partner Sonny Merryman installed electric school bus charging stations in Chesapeake and Ashland, Virginia. They will be energized and in use during the final quarter of 2023.

DCFC Corridor

Greater Washington Region Clean Cities Coalition and project partners identified a site in Maryland for the DCFC corridor installation in 2024. Electric demand charges have arisen as a possible barrier as the project explores non-federal National Electric Vehicle Infrastructure (NEVI) compliant charging.

Vehicle, Port Study, and Deployment Launch

The Port of Virginia continues extensive work toward its sustainability goals, including hybrid shuttle carriers, four electric yard trucks, charging stations, and electric forklifts. Operator feedback has been positive, i.e., "quiet, comfortable ride, gets the job done." The Port of Virginia is also conducting a trucker survey to gather information from partners for two studies: hydrogen and electrification. The Port and Virginia Clean Cities collaboratively launched a limited $200,000 per vehicle zero emission "GO-Zero" incentive for dray truck operators in 2023 through the Green Operator (GO) program, www.greenoperator.org.

Ports Data

Regular standing meetings with Virginia Clean Cities, the Greater Washington Clean Cities Coalition, Port of Virginia, Maryland Port Administration, and Argonne continue with data discussions. The port partners are pursuing electrification pilots and additional reporting for their respective locations. The project team will deliver data outcomes including AFLEET models in the final report.

Rideshare Vehicles

The project partner BGE has 30 EVs currently in use for the rideshare program and is set to deploy all 100 EVs this year. The vehicles already deployed in Maryland have reached one million emission-free miles and have proved to be a very popular option among rideshare drivers. See Figure I.27.3.

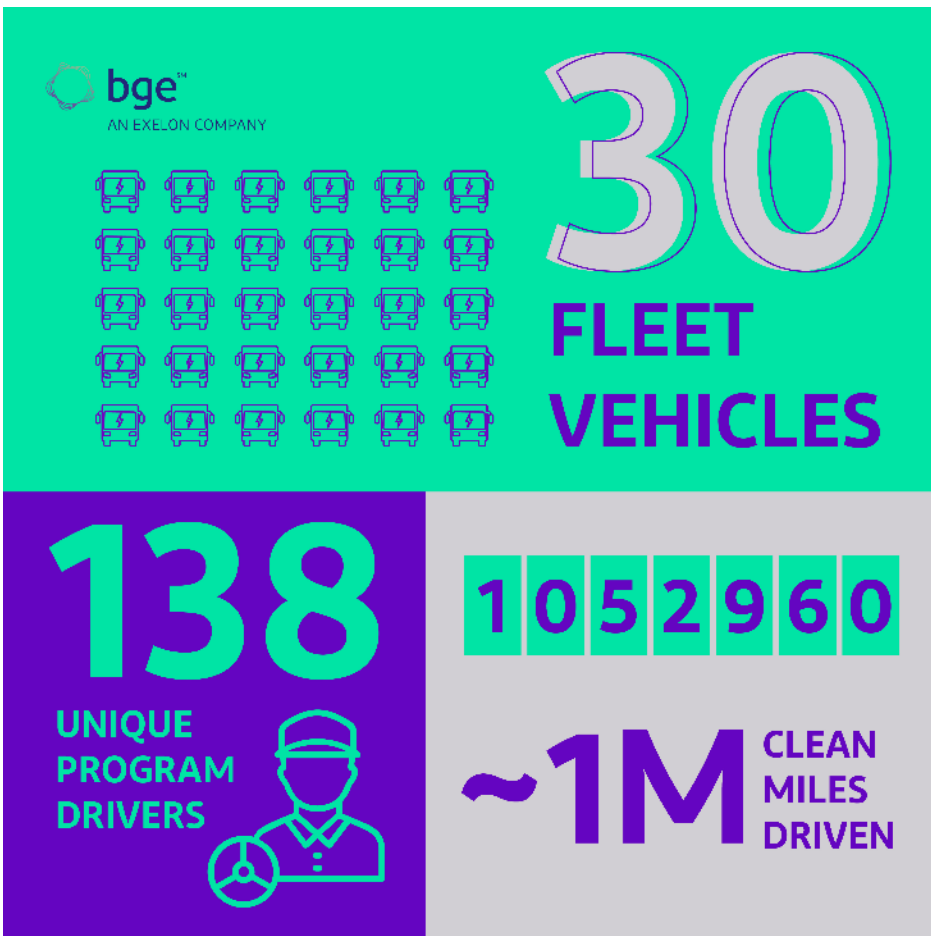

Figure I.27.3 Infographic of BGE's EV ride share program accomplishments.

Geospatial Data

Significant data analysis collection is underway with Argonne and numerous project partners. Some Argonne reports are directly submitted to DOE and not included in this reporting.

Conclusions

The project team continues to implement key subtasks in the second budget period and is achieving milestones in the task areas of EV infrastructure deployment, educational outreach, and analysis. Project partners are collaborating through meetings, events, task completion, and mutual assistance. EVSE deployments have received positive media attention and the project's overall profile has increased. The project is also spurring economic development, i.e., a project partner is expanding its manufacturing presence in Maryland, creating new local jobs. Given this positive momentum, the project has completed Budget Period 2 activities and is ready to move into the final budget period.

Publications

Argonne's Jim Kuiper contributed to the NREL report, "Electric Vehicle Charging Infrastructure Trends from the Alternative Fueling Station Locator: Second Quarter 2023." The report found that at 6.9% the Mid-Atlantic Clean Cities region had the largest increase of any Clean Cities region in the country in public charging infrastructure during the Q2 time period.

Virginia Clean Cities' Alleyn Harned contributed to Generation180's EV report "Your Influence Matters: Peer Influence and EV Adoption."

Acknowledgements

The project team would like to acknowledge Nicole Kirby, Technology Integration Project Manager and Clean Cities Regional Manager at National Energy Technology Laboratory (NETL), for her continued support of this important project.

I.28 Twin Cities Electric Vehicle Community Mobility Network Project (American Lung Association)

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Start Date: October 1, 2020 End Date: December 31, 2024
Project Funding: $13,465,047 DOE share: $6,653,985 Non-DOE share: $6,811,062

Project Introduction

Minnesota’s currently modest success transitioning to electric vehicles (EVs) is due in part to several barriers that hinder broader ownership and use of EVs locally – particularly for those with limited or no access to a garage and/or who cannot afford to purchase an EV. Even for drivers whose vehicle use patterns and income fit well with EV ownership, a lack of public charging infrastructure creates a perceived risk and feeds a narrative of “range anxiety,” which in turn directs consumers away from EVs.
This project deploys electric vehicle supply equipment (EVSE) and EVs in St. Paul and Minneapolis, Minnesota, and the surrounding area (Figure I.28.1). The EVSE deployments include both Level 2 chargers as well as DC Fast Chargers (DCFC). The vehicle deployments support a public carsharing program and dedicated carsharing access at multi-unit dwellings (MUDs). The project also hosts ride and drive events as well as community events to foster a community focused EV network.

Figure I.28.1 Evie Bolt at Saint Paul charging station

Objectives

The objective of this project is to deploy electric vehicle charging and EVs, and provide supporting outreach and education, creating a community focused mobility network that reduces barriers to EV adoption.

The project has the following targets, to be completed by the end of 2024:

- Construct 70 highly visible community charging hubs:
  - Each hub with two dual-port Level 2 EVSE, for a total of 280 ports
  - 12 additional DC Fast Charging ports.
- Deploy 200 shared EVs: 150 vehicles as a one-way carsharing network and 50 vehicles for use by residents at the MUDs.
- Equip 25 MUDs (both low-income and market rate) with charging infrastructure and shared-EV access.
- Conduct 25 ride and drive events near new charging hubs, reaching an estimated 1,500 community members. Produce 10 million estimated media impressions.

Approach

The approach and methodology for this project are based upon the mission, expertise, innovation, and success of the six partners in advancing EV awareness and use and building strong multi-sector partnerships for success. The project activities are a direct outgrowth of the work carried out to date, existing partnerships and networks, and strong knowledge of what is needed to move the EV market forward.

Twin Cities EV Community Mobility Network (now locally referred to as EV Spot Network & Evie Carshare) supports a highly visible, sustainable EV ecosystem in Saint Paul, Minneapolis, and the surrounding seven county metropolitan region. The project makes significant contributions to overcoming market and other barriers, especially in areas that currently have less access to the benefits of electric vehicles. Program logos shown in Figure I.28.2 indicate the difference between the carshare program chargers and the public charging network. Figure I.28.3 showcases one of two program carshare vehicles and the vehicle wrap designed to promote the program locally.

Figure I.28.2 Program Logos

Figure I.28.3 Evie Carshare

All partners involved in the project provide strong experience in building markets and increasing consumer and fleet awareness and acceptance of alternatives to traditional petroleum fuel. The Minnesota Clean Cities Coalition (MC3) oversees the program budget, timeline, and deliverable completion for each sub-recipient. The City of Saint Paul leads the development of the community charging hubs, DCFC installation, and acquisition of the community carsharing vehicles. St. Paul worked with Minneapolis to identify the locations for curbside charging equipment in their respective cities, which is being placed in public rights of way. The cities manage the process of site selection and any internal regulatory process. Saint Paul also worked with partners to lead the vendor selection processes for installing and operating the Level 2 and DCFC equipment, as well as the EV leasing for the community carsharing program. Over the past year Saint Paul staff and partners continue to troubleshoot site construction and installations.

The project created a network of mostly on-street EV chargers to serve Evie carshare and public charging for personal EVs. Each EV Spot includes 4-6 on-street parking spots. Most locations have two dual-port Level 2 chargers, with one charger dedicated to Evie carshare and the other dedicated to public charging. A limited number of locations required additional parking spots to provide fast charging. The EV Spots also include electrical service cabinets in the boulevard, and in some cases an additional transformer cabinet. The network will showcase 38 EV Spot locations in Saint Paul and 32 in Minneapolis.

Within each neighborhood in the service area, project partners continue to work to make the hubs well managed, including overseeing vandalism/cord-cutting and a few homeless encampments. In Minneapolis, the city continues to coordinate siting with its mobility hubs pilot program with the few remaining chargers to be installed in Minneapolis. There have been many logistical factors to consider, including whether there is space available and other city planning activities. Finally, the team has considered hyper-local information such as unmarked loading zones and other local curbside activities for which we would find alternative solutions as part of this project.

HOURCAR continues to lead the overall EV carshare project management for both the community system and the vehicles at MUDs. They coordinate the operation of the programs and upkeep of the vehicles. Staff are dedicated to the transition of their carsharing fleet from internal combustion engines to EVs and oversee the selection and installation of hardware and development of software necessary to maximize the utility of the carshare network. They also have staff devoted to community engagement for the overall project and the development and operation of the carsharing system at MUDs.

Xcel Energy continues to support the planning and installation of the make-ready infrastructure for the remaining dozen community charging hubs, DCFCs, and multiple MUDs, as well as the actual charging equipment at the MUDs. They have evaluated locations to determine suitability and infrastructure needs and coordinate their portions of the installations.

East Metro Strong continues to leverage its public and private members to support the team's work and to find additional operational funding. In addition to aiding the communications teamwork, East Metro Strong works with city and county governments, including Economic Development Authorities, Community Development Authorities, and Public Housing Agencies, to optimize future opportunities and media.

Minnesota Clean Cities Coalition staff continue to bring all areas of work together and ensure deadlines are met, partners are in communication and budget is maintained. Minnesota Clean Cities Coalition staff also complete many ride and drives at large events.

Results

Vehicles

Leveraging strong partnerships has been the main approach for achieving project objectives. 170 vehicles are currently deployed between Saint Paul and Minneapolis. On average there are 115 – 120 vehicles in service on any given day. Vehicle issues are general wear and tear, low charging, or small accidents. As shown in Figure I.28.4 the total trip count of the Evie Carshare program shows regular growth. The blue column indicates Access PLUS trips, by members that indicated their household income is 50% or less of the Area Median Income. Access PLUS is the program's lowest rate plan, designed to keep carsharing equitable. The project aims to address environmental, social, and racial inequities in the transportation system, and to achieve change by providing electric carshare vehicles and related infrastructure through the following goals by 2026:

- 50% use by Black, Indigenous and people of color (BIPOC) members
- 40% use by very low-income members
- 20% use by very low-income and BIPOC members

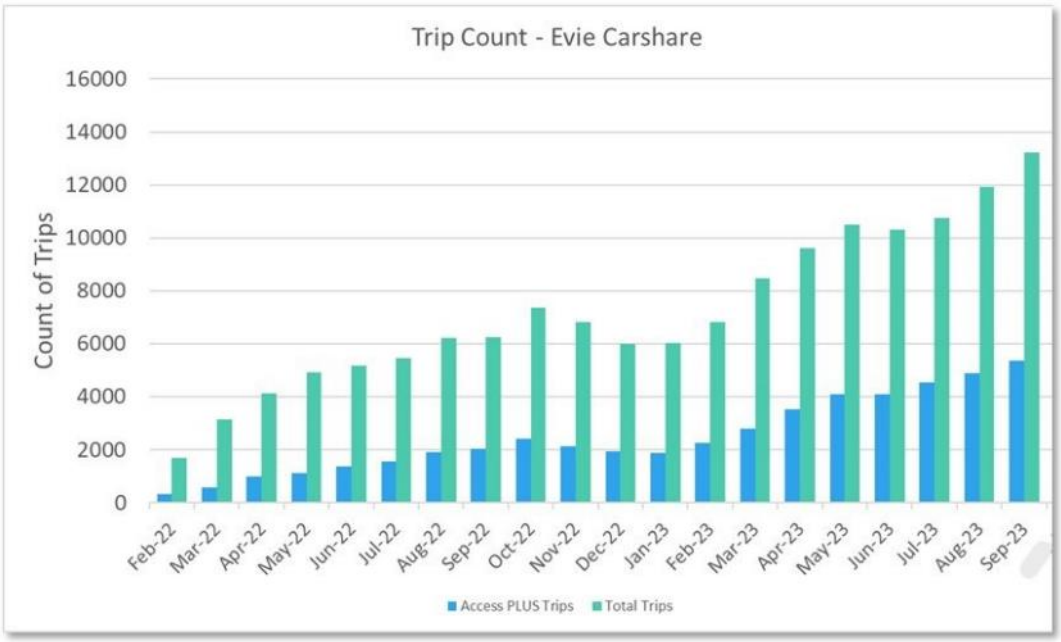

Figure I.28.4 Trip count of Evie Carshare program. February 2022 – October 2023

Community Charging Hubs

For the charging hubs, sites are located curbside in public right of ways. To date there are 59 sites installed and over 55 are activated. Delays in EVSE shipping have been an ongoing challenge in this project as well as transformers. Data in Figure I.28.5 shows energy use and charging sessions use in 2023.

Similarly, partnerships are key to overcoming a variety of local market barriers. Utility engagement has defrayed costs for infrastructure development. Carsharing programs will expand access to electric vehicles for community members and residents of selected MUDs. Data in charts below show energy usage and charging sessions for both the carshare program and the public chargers. Data breakout includes Minneapolis as well as Saint Paul in varying shades of blue and green.

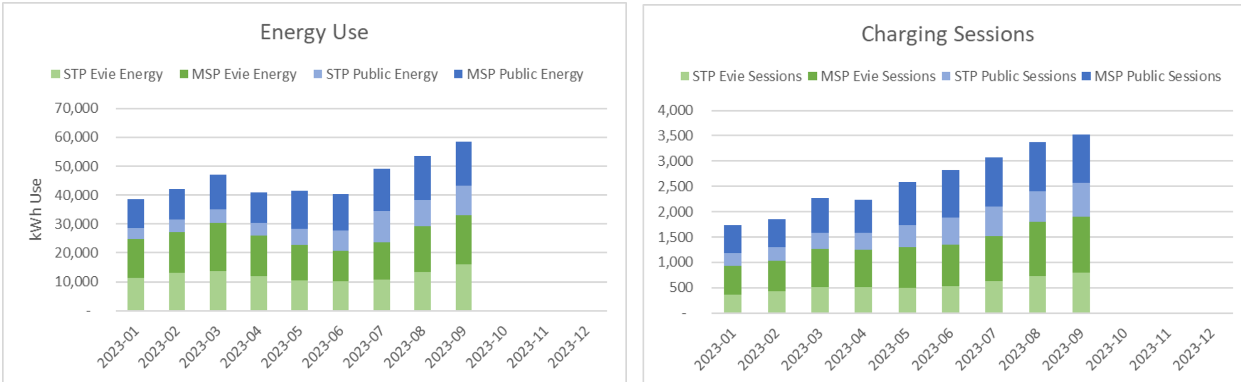

Figure I.28.5 Energy use and charging sessions through September 2023

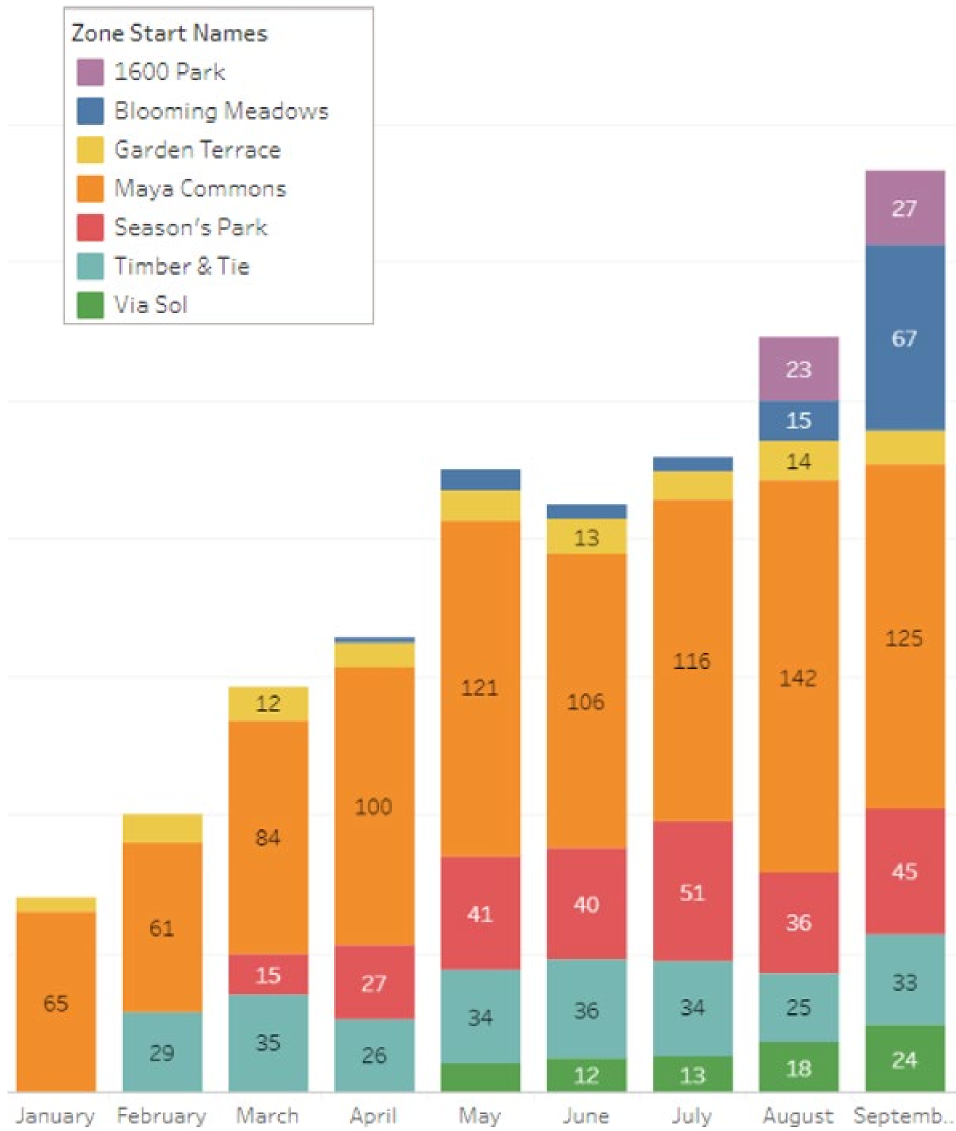

Figure I.28.6 Number of roundtrips from multi-unit locations

Multi-Unit Development Initiative

In the original Statement of Project Objectives (SOPO) we had planned to work with 25 host sites at Multi-Unit Developments. We will scale back the total host sites via an amendment change in Winter 2023 due to the very slow process of site selection, site costs, and issues with vehicle procurement and EVSE installation. EVSE continues to be a very big challenge with equipment availability and shipping delays. Currently seven sites are active with nine sites pending which will be completed mid to late 2024. The number of trips taken each month at the seven current sites is shown in Figure I.28.6. A Request for Proposals is currently open to secure the final nine sites which will be completed by 2025. Nearly every quarter shows great growth.

Education, outreach, and communications

These efforts have raised consumer awareness, provided firsthand experience, and increased the use of electric vehicles in Minnesota. Over 30 events have taken place since October 2022, and more are planned. Minnesota Clean Cities Coalition staff attended Forth Roadmap May 16 – 17, 2023 in Portland, Oregon where we shared program updates during networking events such as the Women of Electric Vehicles (WEV) reception.

Conclusions

The EV Spot Network (formerly referred to as the Twin Cities Electric Vehicle Mobility Network) project supports several key elements necessary to sustain the growth and enduring use of EVs in Saint Paul, Minneapolis, and the surrounding seven-county metropolitan area. Minnesota has ambitious goals for EV adoption. To provide the benefits of EVs to more Minnesotans and to accelerate their rate of use in a long and sustained fashion, new efforts are needed. The main objective of the EV Spot Network is to create the basis for a highly visible, sustainable EV ecosystem in our area. The project has made significant contributions to making the benefits of EV technology broadly available in the Twin Cities region, especially in underserved areas.

The identified solutions in this project are the result of years of work by project partners and additional contributions, insights, and lessons of countless others. This project combines the experience and capabilities of Minnesota's two largest cities, the largest utility, the nation's largest nonprofit carsharing system, and the Clean Cities coalition to complete five mutually reinforcing sub-projects that are rapidly advancing the sustained use of EVs by individuals and fleets in the Twin Cities region.

Construction of highly visible, curbside public charging infrastructure is nearly complete, providing access to Level 2 charging for residents, visitors, businesses, local governments, and taxi/ride-hailing fleets. To date 59 community charging hubs, each with two dual-port Level 2 EVSE, have been installed. 170 EVs are now available to Twin Cities residents and visitors through a one-way carsharing network. 101 Chevy Bolts were available to the public as of August 2021 and 69 Nissan Leafs came to the market in 2022 and 2023.

EV education for residents of MUDs continues with the project providing infrastructure and carsharing at multifamily locations. Seven MUDs in low-income areas have been completed for charging infrastructure and shared-EV access. The project is utilizing education, outreach, and communications to help a wide range of people understand the benefits available to them and their communities through EVs and charging hubs.

Key Publications

HOURCAR "Community Engagement: Report" https://www.stpaul.gov/sites/default/files/Media%20Root/Twin%20Cities%20Electric%20Vehicle%20Mobility%20Network%20Infographic%201%20%28English%29.pdf

HOURCARs 6 Month Report of Evie Carshare Operations: https://eviecarshare.com/report-first-six-months-of-evie-operations/?fbclid=IwAR0_OMz2yybsLinQTIMfVINtzrzBn5c2iFy8Ov49kziRS4vwJ7z-XQtAN6E

The EV Spot Network website: www.EVspotnetwork.com

The Evie Carshare website: https://eviecarshare.com/

Social media accounts on Twitter, Facebook & LinkedIn: @eviec7arshare

I.29 Developing Replicable, Innovative Variants for Engagement for EVs in the USA (DRIVE Electric USA) (East Tennessee Clean Fuels Coalition)

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Start Date: October 1, 2020 | End Date: December 31, 2023
Project Funding: $3,611,809 | DOE share: $1,801,697 | Non-DOE share: $1,810,112

Project Introduction

In early 2020, staff from the East Tennessee Clean Fuels Coalition (ETCF) and Clean Fuels Ohio (CFO) thought, “What if we could get a significant number of largely flyover states together to share in developing plans for building effective Drive Electric programs in all our states?” That question turned into the DRIVE Electric USA (DEUSA) proposal that was selected and awarded by DOE’s Vehicle Technologies Office in summer 2020.

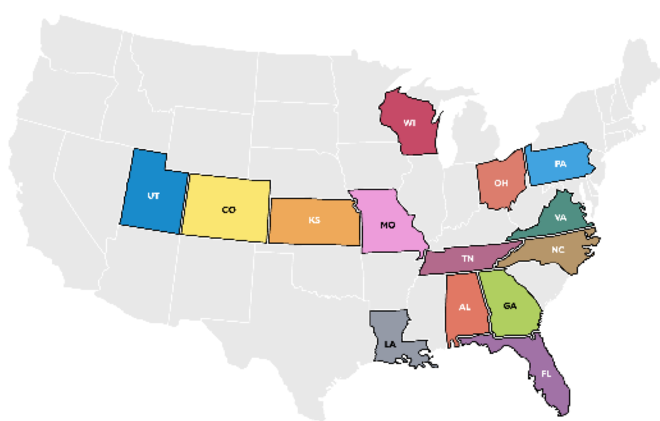

Figure I.29.1 Map of participating states

The project runs from October 2020 through December 2023 (39 months) and comprises a group of diverse stakeholders, including Clean Cities coalitions (coalitions) from fourteen states, many transportation-electrification-related nongovernmental organizations (NGOs), utilities, state and local government departments, and other committed partners who are dedicated to raising awareness and adoption of electric vehicles (EVs) across the USA. The project team will use our states as great and dissimilar examples of how to successfully build statewide, successful EV efforts to overcome common EV adoption barriers and drive the purchase and use of EVs of all sizes and by general citizens and fleets and has made great progress during our first two years. See Figure I.29.1 for participating DEUSA states.

The reason the project was developed is that we have a greenhouse gas (GHG) emissions problem in the U.S., and we are an example to the rest of the world. This project is seeking to increase EV education and adoption across the partner states, many of which are not leaders in EV adoption and likely have anti-EV citizens or groups in their states. This is where localized engagement between those citizens and other citizens in their communities who own an EV can be a way to directly counter EV misinformation and myths.

Objectives

To accomplish the goal of accelerating statewide "Drive Electric" initiatives in these states, project leaders and implementers have started educating consumers, utilities, regulators, and government officials, and engaging auto dealers and fleet leaders, conducting EV infrastructure planning, and developing local EV chapters. All of this is occurring under the banner of each branded, statewide EV effort, which will be guided by that state's stakeholders. Broadly, the DEUSA project will create a Replication Playbook based on outputs and lessons learned that will incorporate appropriate amounts of results from the project work and highlight specific successes from all the participating states. The project also seeks to build successful long-term continuation through funding and partnerships, and that work has begun both at the project-wide level and within each state partnership. All partner states are focused on the following **"Priority Areas"** (PA) of effort, and all the project's deliverables are nested under these seven PAs:

1) Create and strengthen statewide, branded EV initiatives.
2) Educate at least 14,000 consumers through grassroots education initiatives across all states and develop "chapters" of active participants in every state.
3) Build relationships with dozens of utilities of all types and utility regulators and build incentives and investment opportunities.
4) Conduct EV infrastructure planning sessions for corridors and urban and rural areas, including a focus on disadvantaged and limited-income communities.
5) Educate state and local government officials.
6) Create "Certified EV Dealer" programs in every state.
7) Facilitate EV deployments in fleets.

The specific Year 2 deliverables/tasks are provided and discussed in the Results section, and very closely align with the federal FY 2022-23.

Approach

The project team includes ETCF as the Principal Investigator while CFO serves as a "super sub" overseeing the administrative management of the 12 other coalitions that are involved in the project. Both coalitions have significant experience working in various collaboratives and groups towards cleaner transportation initiatives.

ETCF and CFO devised the project and its specific plans to work across the seven Priority Areas and focus on those specific work elements in removing barriers to EV implementation. The team developed specific tasks and subtasks under each Priority Area to allow more and less EV-system-learned coalitions to be able to make solid headway in a) developing transportation electrification partnerships across their states that can serve as effective cornerstones for future and ongoing progress, and b) beginning to work across the remaining Priority Areas to address specific EV-adoption barriers in their states. This project has a total of 57 deliverables/ subtasks for each state/coalition, for a total of 798 deliverables.

The project team holds monthly, internal meetings to discuss deliverables and documentation and to aid coalitions in a group format. Additionally, both CFO and ETCF have communicated directly with coalitions to help them overcome issues in their work. The team has developed a large and significant set of tracking tools to help project leadership as well as individual coalitions see where they stand in completing their deliverables in each of the three project years.

Results

Some occurrences have played a role in slowing project progress. Overall, we have overcome these obstacles, but we appreciate DOE and other project oversight personnel understanding their impact.

- ✓ COVID-19 in the initial year plus reduced the ability of some coalitions/state partners to plan in-person events. Project subtasks like a) holding "convenings" with stakeholders, utilities, government officials and b) setting up events where citizens could directly see and ride in or drive EVs were delayed. In some cases, coalitions set up virtual meetings via tools like Teams or Zoom to hold those meetings, but those cannot compete with in-person meetings to really forge strong relationships, and many coalitions understand that it set back their efforts to build those new or stronger connections and relations.
- ✓ Major project leader Sam Spofforth, the Chief Executive Officer of CFO – who helped devise the project – departed CFO at the end of 2021 (the end of Y1 in the project). He was the main partner with ETCF's Executive Director Jonathan Overly in managing administrative and programmatic project work. He was significantly involved in the search for funding to turn this project into a more robust program. His departure considerably delayed the work he and Overly were doing to develop long-term, top-level funding for the coalition. While Overly continues this role alone and is making progress in multiple funding opportunities, Spofforth's departure absolutely impacted the project.
- ✓ The primary project fiscal oversight staff at CFO changed four times in 2022. Megan Stein, another excellent CFO staff person, left in early 2022, and it has taken CFO some time to find its bearings. Other staff left as well, and CFO essentially went through not one but two changes in leadership in less than two years, which was the meat of the project period. Although ETCF has been able to work through these personnel changes, it did delay the process of CFO receiving, reviewing, and handling invoices as needed.

The federal fiscal year 2022-23 overlaps 9 months with the project Year 3, so we are showing those goals while also referencing where necessary Year 2 outputs or outcomes. Below are the specific subtasks that all the coalitions/states undertook in Year 3. The vast majority are the subtasks for *each* state.

Task 3.1 – Build and Strengthen Branded State EV Initiatives

3.1-A = Perform outreach and marketing of statewide Drive Electric initiative and document at least 200 social media engagements and 40,000 media impressions. In the first two years of the project, DEUSA significantly exceeded our project-wide goals for social media engagements and impressions. (Table I.29.1). The Year 3 results will not be fully realized until December 2023, but we expect to have no problems surpassing our Year 3 goals.

Table I.29.1 Years 1 & 2 Engagements and Impressions – Original Goals, and Realized

	Goals	Realized
Y1 engagements	1,400	73,540
Y1 impressions	280,000	15,470,832
Y2 engagements	2,800	31,125
Y2 impressions	560,000	26,776,521

Task 3.2 – Educate Consumers and Build Local EV Initiative Chapters

3.2-A = Through in-person outreach activities, document direct engagements with at least 400 consumers. This is a similar situation to Task 3.1; while COVID did impact some coalitions' ability to hold outdoor, in-person events, overall, our 14-state-wide direct engagements went very well in the first two years, and with more time under their belts to further establish new chapters, Year 3 should be even better. (Table I.29.2).

Table I.29.2 Years 1 & 2 Direct Engagements – Original Goals, and Realized

	Goals	Realized
Y1 direct engagements	2,800	16,322
Y2 direct engagements	5,600	64,739

3.2-B = Hold meeting with ETCF to highlight your new chapter counties on whole US map. We needed to be able to show our impact country wide, so we produced a map showing the status of chapter development (Figure I.29.2). All states' contributions to chapter development are shown.

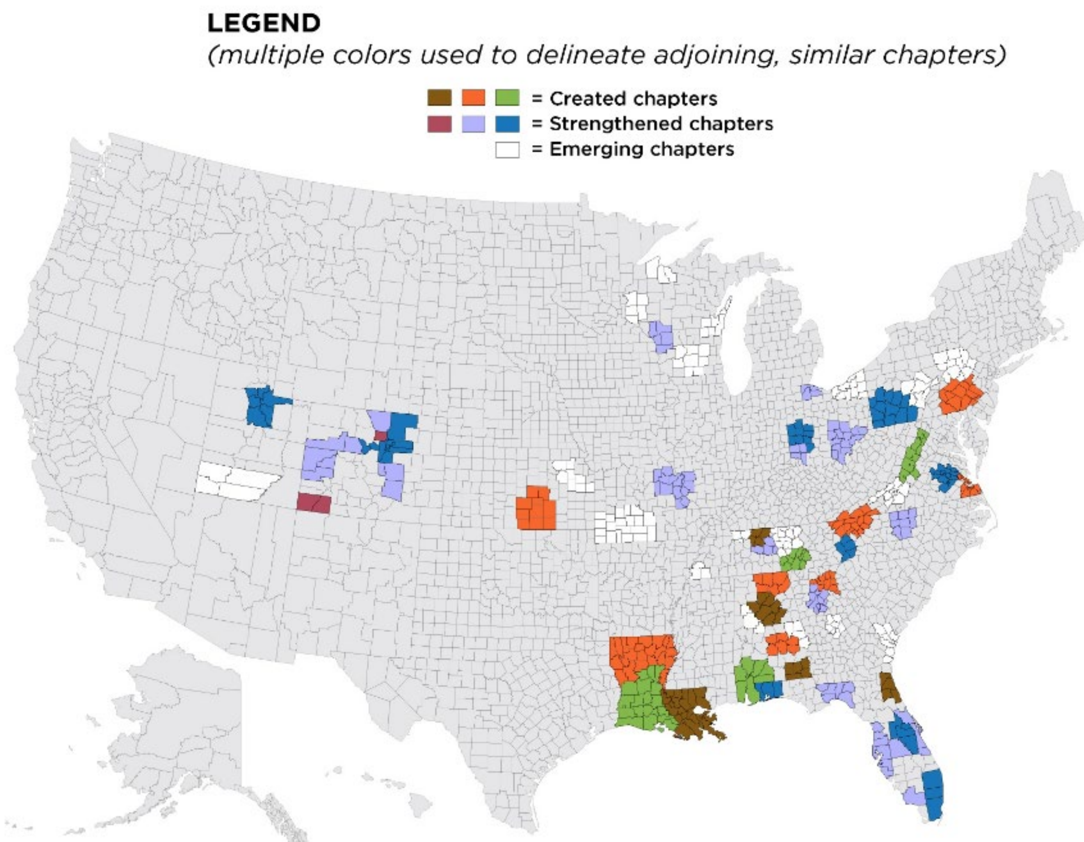

Figure I.29.2 Map of DEUSA states and the created or strengthened local EV chapters.

Task 3.3 – Build Utility and Regulator Support for Transportation Electrification

3.3-A = Hold at least two convenings with utilities and regulators and document engagements. Coalitions have been doing some great work with their utilities. Some example FY 2022-23 accomplishments include:

- Drive Electric Louisiana met with Entergy Louisiana, Cleco Power, and DEMCO Coop over four meetings January-March 2023.
- Electrify Heartland (Kansas and Missouri) worked with Evergy (the utility that provides electricity in large swaths of the two states) to hold multiple Ride & Drives between October 2022 and March 2023.
- Drive Electric Colorado met bi-weekly with Xcel Energy and discussed EV charging programs and rebates.

Task 3.4 – Conduct/Update EV Gap Analyses and Plans in Each State

3.4-A = Conduct at least three community electric vehicle supply equipment (EVSE) gap analyses and create plan with recommendations on priority EVSE needs and locations. Coalitions worked hard on this subtask as well, and examples of interactions include the following.

- Drive Electric Tennessee worked in Pulaski, Morristown, and Memphis, Tennessee to help the utilities, local leaders, and others gather ideas and map them out for community Level 2 and DC Fast Charging units in places where they are most needed.
- Drive Electric Ohio decided to do micro-level "community" analyses and worked with the Columbus Zoo, Worthington, Ohio (a small suburban city north of Columbus), and a nonprofit called "I Am Boundless" to help them plan out charging needs.

Task 3.5 – Educate Governments Officials about EV Policy Best Practices

3.5-A = Hold convenings with local government officials in at least 3 communities and document engagements. Many government interactions took place, including:

- Drive Electric Virginia had meetings with officials from Alexandria who are interested in curbside EV charging ordinances; the Town of St. Paul, Virginia to help them identify two sites for EVSE; and Town of Radford, Virginia to discuss funding opportunities for charging stations.
- Drive Electric Georgia collaborated with two other entities to offer two, two-hour trainings on EV Basics & Mythbusting, and offered those to the Association of County Commissioners of Georgia on April 30, 2023, and to the Georgia Municipal Association on June 23, 2023.

Task 3.6 – Develop Preferred Dealer Programs and Secure Participating Dealers

3.6-A = Update websites with list of preferred dealers and contact information on each state's initiative website. All the states have completed developing their maps or lists of preferred dealers and have added new dealers in 2023. See the initiative websites wherein you can find their lists/maps.

3.6-B = Connect preferred dealers to Research and Development (R&D) events hosted by the statewide programs and connect consumer participants in R&D events with preferred dealers. Examples of this work in 2023 include the following:

- Drive Electric Georgia worked with the Georgia Auto Dealers Association to connect dealers to one large event in April 2023, and two events in September 2023.
- Drive Electric Utah connected multiple dealers to the local chapter and to many new area citizens around Logan, Utah through a Utah State University "ASPIRE" Program event.

Task 3.7 – Drive Fleet Adoption of EVs and Infrastructure

3.7-A = Finalize report on activities to engage 50 fleets or more in education, outreach, and EV/EVSE Deployment.

3.7-B = Hold convenings and directly engage at least three (3) fleets in EV and EVSE deployments. States and their leaders have finished 50 fleet engagement reports and engaged many fleets directly during the project period. Specific stories of engagement can be found on the website, and in 3.7-C.

3.7-C = Produce Fact Sheet and/or "Success Stories" of at least 10 Fleets that have deployed EVs in the State. This was a MAJOR subtask in our Year 3 work, and we underestimated the amount of time this would take to complete. We decided to keep the stories short – on the order of 2-4 pages – as long as the writers could provide all the needed details (who/what/when/where/why/how) in short order. Part of the underestimation was that in some cases, fleets are taking weeks or longer to get any suggested edits returned. However, we do expect to complete this by the end of the year. Most importantly, we are putting ALL 140 of the stories on the DEUSA website, here. You can see them there on a map that highlights where the stories are, and then in a state-by-state listing of the stories.

Task 3.8 – Build Replication Playbook and Secure Continuation Funding for State Initiatives

3.8-A = Review your state's website with project leadership to make final project-based enhancements or changes. During the first part of 2023, we held one-on-one meetings with the leadership in each state to review their initiative's website to ensure that about eight specific things that were part of the project were being included, implemented, or shown. Most of the sites had all these items included as of June 2023, but a couple of websites are still finishing.

3.8-B = Hold an All-coalition discussion on DEUSA Success Stories (webinar), where each state has a person present their state's story. This webinar will take place on November 29, 2023. Each state will present on one of their Priority Areas and provide a 5 to 6- minute presentation on their work in that Priority Area.

3.8-C through 3.8-E = Produce Your State's SUCCESS STORIES #1, #2 and #3 for Replication Playbook. For the Playbook, we determined that each state would produce three stories, with one each coming from their work in the seven project Priority Areas. ETCF set up a format that included a narrative, outputs and outcomes, and best practices and lessons learned. About one-third of the success stories have been completed as of September 2023. The final deadline is the end of the year, and we will have both a PDF version of the Playbook as well as PowerPoint slides or perhaps an ArcGIS story map.

During FY21, ETCF's Overly and CFO's Spofforth began the process of reaching out to *other, new* states to join in the efforts to develop statewide, branded "Drive Electric" initiatives, including getting them to sign a Memorandum of Understanding about interest and future involvement. In late 2021 and early 2022, that process turned into a) developing a larger sponsorship program, and b) working on a new proposal to bring more states in via funding very similar to that of the original project. DEUSA presented a format proposal to DOE which was awarded in summer 2023. Figure I.29.3 shows the original 14 states plus the new 13 that are part of the "DEUSA2" project.

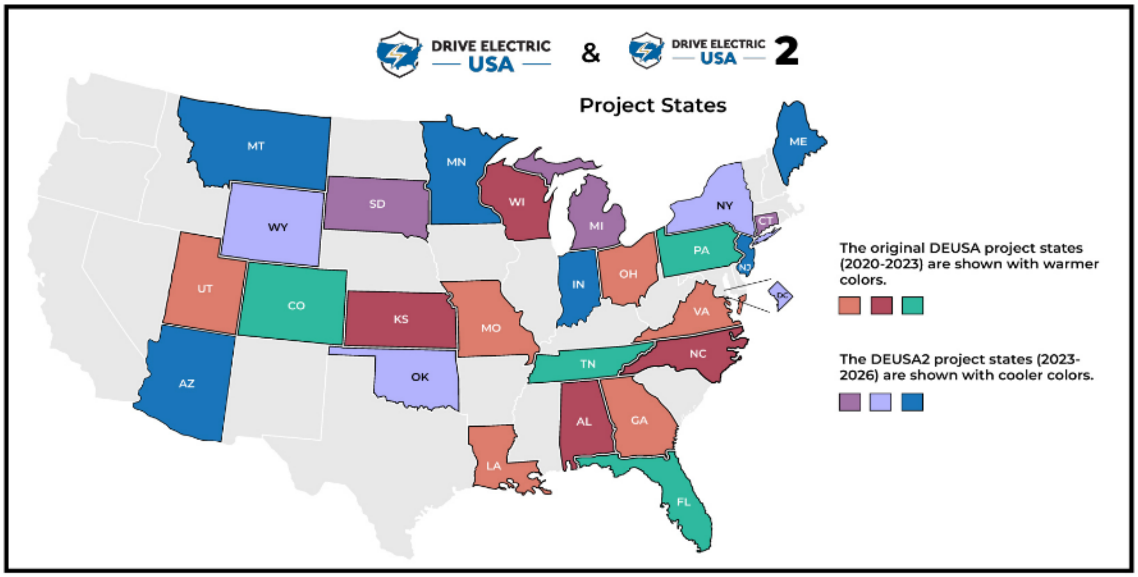

Figure I.29.3 Map of DEUSA states plus the new "DEUSA2" states

Conclusions

As can be seen from the above information, our partner states are engaging on many fronts. Some of the project outputs and outcomes are provided, but even more will be developed in the final Replication Playbook and fleet stories that are yet to come, and that will be visible to anyone who visits the project website.

Key Publications

Drive Electric USA website, www.driveelectricusa.org, as well as all the other state initiative websites which are linked to the DEUSA website.

Acknowledgements

We are very grateful for the partnership with CFO in managing this grant. Multiple staff there have been instrumental in assisting in effective project development, planning, and execution. Thanks also to all the coalitions that have been involved to help us all bring about these valued and helpful statewide "Drive Electric" programs. We also appreciate the suggestions and guidance of our DOE Project Officer Trev Hall for his contributions to the success of the project.

I.30 Helping Rural Counties Transition to Cleaner Fuels and Vehicles (Transportation Energy Partners)

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Start Date: October 1, 2020 End Date: December 31, 2024
Project Funding: $2,160,562 DOE share: $1,078,581 Non-DOE share: $1,081.981

Project Introduction

This project provides education and technical assistance to help public and private sector fleets in 24 rural and underserved counties transition to cleaner fuels and vehicles.

While an increasing number of urban communities are exploring alternative fuels and advanced technology vehicles, most rural county governments continue to use traditional gasoline and diesel to power their fleet vehicles. Moreover, significant barriers challenge county leaders who may be interested in exploring new technologies. Rural county governments often lack the staff capacity to learn about new technologies, implement new training and maintenance systems, and educate their workforces. The lack of funding and financing options, combined with staff capacity to research and pursue existing incentives, can also be a significant barrier. Even when there is a positive return on investment in terms of reduced fuel and maintenance expenses, the upfront costs required to purchase alternative fuel vehicles and install fueling infrastructure can prevent many county governments from making the transition.

Transportation Energy Partners is coordinating and supporting Clean Cities coalitions in eight states to identify and work with rural county leaders to understand and seek to overcome these and other barriers and find models that work for increasing adoption of cleaner fuels and vehicles.

Objectives

The objective of the project is to create models for effectively transferring advanced clean fuel and vehicle technologies to underserved county governments and rural communities and then share those models and lessons learned through a nationally distributed Replication Playbook.

Approach

The project team, led by Transportation Energy Partners, with Clean Fuels Ohio as a key administrative partner, will provide outreach, education, and technical assistance to government fleets in rural regions in Ohio, Indiana, Wisconsin, Virginia, Alabama, Utah, Oregon, and Washington. The project will span at least 24 counties to help them transition government fleets and private fleets in their communities to cleaner fuels and vehicles. Replicable successful strategies and lessons learned will be circulated to other states and regions across the country. The project includes three major areas of activity:

Outreach and Education: Within the first budget period, the project team conducted outreach and education to county government leaders, with the objective of identifying at least 24 county governments that will receive technical assistance.
In-Depth Technical Assistance: Within the second budget period, the project team is providing technical assistance, including workshops, fleet assessments, and vehicle demonstrations, to help county and private fleets transition to cleaner fuels and vehicles.

Dissemination of Project Findings: Within the third budget period, the project team will develop and disseminate a Replication Playbook to highlight successes and provide an action plan to project states, county leaders, rural communities, and fleets across the country.

Results

The project team continued to make progress on all Budget Year 2 milestones:

- Milestone: Completed 13 fleet assessments in target communities.
- Milestone: Held 14 clean fuel and vehicle workshops or meetings with fleets from target communities.
- Milestone: Completed 27 vehicle demonstrations at events or with fleets in target communities.

The project is making good progress toward meeting the goals and objectives for the technical assistance phase by December 31, 2024.

Clean Cities Coalitions gathered fleet data and completed and presented fleet assessment reports for about half of the target communities. The project teams are finishing up most of the remaining analyses and reports for presentation to the target communities. Two communities have yet to provide complete fleet data. Table I.30.1 lists completed assessments.

Table I.30.1 Fleet Assessments Completed

Assessment Completed for:	Project State
Alabama State Parks	Alabama
Spencer County	Indiana
Monroe County	Indiana
Warrick County	Indiana
Muskingum Watershed District	Ohio
City of Sandusky	Ohio
City of Portsmouth	Ohio
Moab	Utah
Washington County Sun Transit Authority	Utah
Springdale City	Utah
University of Mary Washington	Virginia
City of Fredericksburg	Virginia
Virginia State Parks	Virginia

Clean Cities Coalitions conducted fourteen clean fuels and vehicles workshops or meetings, bringing the total number of workshops/meetings held to 22 for Budget Year (BY) 2. Table I.30.2 shows events held in FY 23.

Table I.30.2 Clean Fuels and Vehicles Workshops/Educational Meetings

Technical Assistance Community	Project State
Alabama State Parks – May 2023 annual convention	Alabama
Breakfast workshop with rural communities – Dec. 2022	Indiana
Tuscarawas County workshop – Nov. 2023	Ohio
Muskingum Watershed at Terra State workshop – April 2023	Ohio
Portsmouth Workshop – May 2023	Ohio
Lane County Green Truck Summit & Expo (GTSE) rural workshop and meetings – Aug. 2023	Oregon

Technical Assistance Community	Project State
Weyerhaeuser rural fleet GTSE workshop and meetings – Aug. 2023	Oregon
Springdale Zion clean energy event – April 2023	Utah
Southern Utah rural school districts event– June 2023	Utah
Zion Park and Zion Discovery Center Event – Aug. 2023	Utah
City of Fredericksburg workshop – Oct. 2022	Virginia
Thurston County GTSE rural workshop and meetings – Aug. 2023	Virginia
Weyerhaeuser GTSE rural workshop and meetings – Aug. 2023	Washington
Annual Meeting Rural Listening Session – Oct. 2022	Wisconsin

Vehicle partners and Clean Cities coalitions completed 27 vehicle demonstrations this year, bringing the total completed vehicle demonstrations to 35 for BY 2. The coalitions have plans to complete the five remaining vehicle demonstrations by December 31, 2023. Communities have expressed appreciation for the ability to see and drive demonstration vehicles. The logistics of getting project partners' vehicles to events has proven challenging, and coalitions have sometimes relied on local partners and other stakeholders to loan vehicles for communities to see at events. In some cases, vehicles were on display but were not available for fleets to drive. Table I.30.3 shows the range of vehicles made available at events and/or for fleet demonstrations.

Table I.30.3 Vehicles Utilized for Demonstration Events or Fleet Demos

Demo Vehicle	Event or Fleet Demo	Project State
Alliance AG propane pick- up truck	State Parks event, Marion Co. fleet demo	Alabama
F-150 Lightning electric truck	State Parks event	Alabama
Electric school buses	Clay County School District demo	Alabama
Lightning eMotors shuttle van	Demo event	Indiana
Thomas electric school bus	Spencer County, Monroe County school district demos	Indiana
Ford Mustang electric vehicle	Rural Sustainable Energy Day	Indiana
STAG USA pick-up (CNG/Propane conversion)	Rural Sustainable Energy Day Terra State workshop	Indiana, Ohio
Propane police cruiser	Muskigum Watershed Event	Ohio
Battle Motors electric refuse truck	Tuscararawas workshop	Ohio
Audi eTron	Terra State workshop	Ohio
Ford Escape propane	Terra State workshop	Ohio
Kenworth/Toyota T680FCEV	GTSE	Oregon/Washington
Volvo electric compact excavator	GTSE	Oregon/Washington
Westfort Fuel Systems LNG Truck	GTSE	Oregon/Washington
Navistar electric school bus	GTSE	Oregon/Washington
Green Kraft MD propane truck	GTSE	Oregon/Washington
MachE police interceptor	GTSE	Oregon/Washington
Ford Lightning electric truck	GTSE	Oregon/Washington
DANNAR electric remote unit	GTSE	Oregon/Washington
Mack electric garbage truck	GTSE	Oregon/Washington

Demo Vehicle	Event or Fleet Demo	Project State
Alliance AG propane pick- up truck	State Parks event, Marion Co. fleet demo	Alabama
ROUSH propane school bus	City of Fredericksburg workshop	Virginia
Bluebird electric school buses	City Fredericksburg workshop	Virginia
Starcraft electric paratransit van	City of Fredericksburg workshop	Virginia
Ingevity Ford F-250 (ANG)	Annual meeting and rural listening session	Wisconsin

Conclusions

The Helping Rural Counties Transition to Cleaner Fuels and Vehicles project accomplished many of its BY 2 technical assistance phase goals and objectives and is on track to complete them all by the end of December 31, 2024, within the project budget. The project team is learning and adapting to meet the unique needs of small and rural communities that are interested in exploring clean fuels and vehicles.

Acknowledgements

We want to thank our partners at Clean Fuels Ohio for their incredible administrative and technical support for the project so far, as well as our incredible Clean Cities coalitions and industry partners for helping make important strides in reaching rural communities to engage them in our project and encourage exploration of cleaner fuels and vehicles.

I.31 NFPA Spurs the Safe Adoption of Electric Vehicles through Education and Outreach (National Fire Protection Association)

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Start Date: October 1, 2020 End Date: June 30, 2024
Total Project Cost: $ 1,356,176 DOE share: $678,087 Non-DOE share: $678,089

Project Introduction

Even as the popularity of electric vehicles (EV) and their charging infrastructure has been increasing across the U.S., numerous barriers continue to impede their true potential for rapid growth in contrast to other countries such as Norway, Iceland, Sweden, and the Netherlands. According to CleanTechnica.com, 2018 was the best year in the U.S. for EV sales; however, they have slowed ever since, even in California—long considered at the forefront of adoption. The challenges are numerous: a general lack of public knowledge around EV systems themselves, a deficiency of local incentives to purchase EVs, range anxiety and the necessity for more charging station installations, the need for EV maintenance garage and charging installation safety practices, gaps in code compliance education, insurance concerns, and emergency responder risks associated with damaged lithium-ion batteries. Few U.S. communities have taken the time to assemble their local EV ecosystem (local government, utilities, electrical code officials, manufacturers/dealerships, fleet owners, garages/maintenance facilities, insurance companies, the fire service, EMS, law enforcement, and vehicle owners) to assess their EV preparedness and to develop a plan to integrate, educate, and incentivize this emerging technology into their municipalities, which would raise awareness and speed the adoption of EVs across the country. The National Fire Protection Association (NFPA) believes we, in partnership with the U.S. Clean Cities Coalitions (CCC) network and each community's EV ecosystem stakeholders, will make a significant contribution to jump-starting EV adoption again across the U.S through this project.

Objectives

NFPA believes that increased EV community preparedness planning and collaboration among ecosystem stakeholders will result in a greater understanding of these vehicles and their benefits, more incentives for ownership, increased safety, and a more accommodating infrastructure. Once that has been achieved, increased EV adoption on our nation's roadways is inevitable.
NFPA's goals for this project are to:

1) Augment its world-class web-based EV training programs to include additional modules for all EV ecosystem stakeholders for whom NFPA training has not been previously available (e.g., charging station installers, code officials, utilities, dealerships, fleet owners, garages/maintenance facilities, insurance companies, and vehicle owners). NFPA will also expand its existing crash reconstruction and tow and salvage operator programs to reflect the latest safety knowledge and tactics.

2) Develop a U.S. Clean Cities Coalitions (CCC) digital facilitation toolkit (consisting of a lesson plan, PowerPoint, videos, and scenario/assessment worksheets) and an EV public overview course (expounding on the make-up, benefits, and safety aspects of these vehicles).

3) Advise and assist selected CCCs that will be responsible for conducting approximately 30 EV Community Preparedness Workshops to which they will invite their local communities' EV ecosystem stakeholders. These workshops will be held over a two-year period across the country, bringing together CCCs and EV ecosystem stakeholders to set up cooperative plans and provide education that will spur on greater private and public acceptance of purchasing and accommodating these vehicles in each community.

Approach

To achieve the goal for this 45-month project, NFPA detailed 15 tasks that support successful completion of the established project objectives. See Table I.31.1, Project Approach.

Table I.31.1 Project Approach

Project Tasks	Description
Project Management and Planning	Develop and maintain the Project Management Plan (PMP).
Kickoff Meeting	Participate in a project kickoff meeting with the DOE within 30 days of project initiation.
1) Hire Subject Matter Experts (SMEs) Knowledgeable in EV & EVSE Technology	Hire experienced EV safety SMEs to research and collect content.
2) Hire a Training Development Team	Locate & contract with an experienced web training developer.
3) Conduct Virtual Project Kickoff Meeting	Organize, invite, and moderate the project kickoff meeting attended by project SMEs and project partners with the goal of confirming project scope and determining gaps in existing EV knowledge.
4) Collect Existing EV Content, Research, and Testing	Collect and refine existing EV content including research, testing, codes & standards, and other pertinent literature.
5) Develop EV Workshop Toolkit	Conceptualize and build a comprehensive and highly engaging EV Community Preparedness Workshops curriculum and toolkit
6) Develop/Revise Curriculum Outlines for EV Training Video Modules	Build comprehensive EV training video module curriculum outlines for code officials, charging station installers, utilities, fleet owners, manufacturers/dealers, garage maintenance facilities, insurers, and the public/vehicle owners. Revise existing outlines for NFPA's crash reconstruction and tow and salvage operator programs.
7) Develop/Revise Storyboards and Scripts for EV Training Video Modules	Develop scripts and storyboards for the code official, charging station installer, utility, fleet owner, manufacturer/dealer, garage maintenance facility, insurer, and public/vehicle owner video modules. Revise scripts and storyboards for NFPA's crash reconstruction and tow and salvage operator programs.
8) Produce EV Training Video Modules	Produce the final EV Training video modules for the code official, charging station installer, utility, fleet owner, manufacturer/dealer, garage maintenance facility, insurer, and public/vehicle owner audiences. Update NFPA's existing crash reconstruction and tow and salvage operator programs.
9) Develop EV Workshop Communication and Delivery Plan	Develop a nationwide EV Community Preparedness Workshop Communication and Delivery Plan detailing workshop regions/location, and a master plan for community outreach and engagement.
10) Final EV Workshop Communication and Delivery Plan Completed	Deliver a final EV Workshop Communication and Delivery Plan to effectively propogate the planning sessions and courses.

Project Tasks	Description
11) Coordinate and Schedule ≥15 EV Community Preparedness Workshops	Coordinate and schedule EV Community Preparedness Workshops in pre-determined regions/locations (found in the master plan for community outreach and engagement).
12) Deliver ≥15 EV Community Preparedness Workshops	Coordinate with event host coalitions before, during, and after EV Community Preparedness Workshops to ensure successful delivery of approximately 15 workshops. This includes pre-event training and preparation, day of event logistics, and post event feedback.
13) Compile Feedback	Collect participant and host feedback & evaluations from each coalition host and incorporate into a milestone report.
14) Coordinate and Schedule ≥15 additional EV Community Preparedness Workshops	Coordinate and schedule EV Community Preparedness Workshops in pre-determined regions/locations.
15) Deliver ≥15 additional EV Community Preparedness Workshops	Coordinate with event host coalitions before, during, and after EV Community Preparedness Workshops to ensure successful delivery of events. This includes pre-event training and preparation, day of event logistics, and post-event feedback.

Results

During the second budget year of this project, NFPA took the 10 previously developed EV online training modules for the audiences of charging station (EVSE) installers, code officials, utilities, dealerships, fleet owners, garages/maintenance facilities, insurance companies, tow and salvage operators, crash reconstruction teams, and vehicle owners, and made them available to selected Clean Cities coalitions across the country. All the workshop courses listed above are available and reside in NFPA's learning management system (LMS), which allows learners access to the training from NFPA.com, as well as the newly created www.ReadyForEVs.com website, as participant preparation before each Workshop is held. NFPA's LMS provides NFPA and its project partners access to the course completion data and allows reports to be generated on who has participated in these workshops.

NFPA also made the EV Community Preparedness Workshop course and materials available to the same selected Clean Cities coalitions. The materials provide direction, scripts, videos, and table-top activities to run successful Planning Workshops. The Workshop toolkit includes the Facilitators Guide (22 Pages), Participant Journal (23 Pages), Trainer's Guide (12 Pages), and a PowerPoint Presentation (33 Slides).

Next, NFPA worked closely with East Tennessee Clean Fuels (ETCF), Virginia Clean Cities, and Central Florida Clean Cities, which in turn notified the selected 30 EV workshop coalition hosts to begin preparations for their participation in the project. A few have backed out in the last year; however, to date, ETCF has scheduled 27 EV Community Preparedness Workshops with Clean Cities coalitions.

ETCF disseminated key event-related logistics to coalition partners, including information about "train-the-facilitator" virtual sessions that provide an overview of the 'EV Community Preparedness Workshop' curriculum to each of the host coalitions. NFPA scheduled a Subject Matter Expert (SME) to join each workshop virtually, to provide support for the Workshops and code and EV knowledge. Over the past year, ETCF and NFPA moved ahead and successfully held 23 Workshops across the country.

As mentioned above, the www.ReadyForEVs.com website is the repository for all of the Workshop information and locations and serves as a centralized hub for EV preparedness, including links to NFPA's online EV training modules, event participant registrations, and participant communications. As event details were finalized with hosting workshop coalitions, they were included on this site for registration and registrant tracking.

During 2023, ETCF successfully scheduled and planned a total of 27 EV Community Preparedness workshops, 4 of which have yet to take place. To support these efforts, NFPA continued to hold bi-weekly team meetings with ETCF, Virginia Clean Cities, and Central Florida Clean Cities. The focus of these meetings was to identify, assign, and complete all planning and logistics activities to ensure the successful delivery of scheduled workshops.

NFPA developed a post-event survey, and then deployed it to those participating in the Workshops, providing valuable insights to the project team. This survey and other feedback received helped NFPA decide to rework the curriculum in Budget Period 1, and to shorten the workshop and make it more relevant for participants. NFPA then deployed the revised workshop curriculum to Budget Period 2 workshops, resulting in even greater success measured by the feedback forms collected. The team involved in the development of the program saw this as a victory of engaging the stakeholders and piquing their interest enough to see additional planning take place outside of the project's planned events. Many such meetings reportedly occurred.

NFPA, ETCF, Virginia Clean Cities, and Central Florida Clean Cities together have identified, planned, and successfully completed the following Clean Cities Coalition EV Community Preparedness workshops during Budget Period 2. See Table I.31.2: Completed Workshop Locations.

Table I.31.2 Coalition/Host

Coalition/Host
East Tennessee Clean Fuels (ETFC)
Granite State Clean Cities
Northern Colorado Clean Cities
Clean Communities of Central New York
St. Louis Clean Cities
East Bay Clean Cities Coalition
Middle-West Tennessee Clean Fuels Coalition
Virginia Clean Cities (held 2 workshops for 2 different communities)
Empire Clean Cities
North Dakota Clean Cities
Clean Cities - Georgia
Eastern Pennsylvania Alliance for Clean Transportation
Utah Clean Cities
Drive Clean Indiana
Clean Communities of Western New York
Pittsburgh Region Clean Cities
Central Florida Clean Cities Coalition
Wisconsin Clean Cities
Clean Fuels Ohio
State of Delaware Clean Cities
Central Kansas Clean Cities
Alabama Clean Fuels Coalition

Conclusions

During the second Budget Period, NFPA has accomplished the following toward this project's goals:

- Continued to make the 10 EV community preparedness online training tracks available for free to the selected Clean Cities coalitions and Workshop participants.

- Continued to host the www.ReadyForEVs.com website as a landing page and repository for all workshop materials, trainings, registrations, and communications.
- Continued to make the EV Community Preparedness Workshop course and materials available, including table-top exercises and curricula, to the Clean Cities coalitions hosting these workshops for their surrounding communities nationwide.
- Through our partnering Clean Cities coalitions, NFPA has conducted targeted outreach to identify and schedule 27 appropriate virtual EV Community Preparedness workshop hosts and locations.
- Successfully ran 23 EV Community Preparedness workshops across the country and planned an additional 7 workshops to be run in the first half of 2024.

I.32 Creating the NFPA Distributed Energy Resources Safety Training (DERST) Program (National Fire Protection Association)

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Start Date: June 1, 2021 End Date: December 31, 2024
Total Project Cost: $ 1,182,966 DOE share: $1,039,244 Non-DOE share: $143,722

Project Introduction

Distributed Energy Resources (DER) are small geographically dispersed electricity generators that are connected to a local distribution system. DERs can include solar panels, energy storage systems, small gaseous fueled generators, electric vehicles, and controllable loads, such as HVAC systems and electric water heaters. First responders will confront DERs in abnormal events such as fires, chemical releases, mechanical damage, water immersion, etc.

During an emergency event, the National Fire Protection Association (NFPA) wants to ensure responders are properly trained to make correct tactical decisions, to optimize protection of life, ensure incident stabilization, and conserve property. First responders must understand control systems and the individual technologies involved with DERs, as well as their interconnections of how to approach an incident scene. NFPA is in the process of developing a suite of solutions to support the rapid growth of clean energy technologies, by training and educating firefighters, first responders, and other relevant emergency response professionals. Ensuring that these stakeholders understand DER technologies—especially the inherent risks and ramifications of responding to DER incidents—will be key to furthering acceptance and implementation of DERs in the U.S.

For more than a decade, NFPA has been committed to developing and delivering DER safety training (DERST) for our nation’s emergency responders. Currently offering the most popular U.S. responder programs on energy storage systems (ESS), photovoltaics (PV), electric vehicles (EVs), and electric vehicle power supply equipment (EVSE), NFPA’s objective is to take its existing DER training resources to a whole new level by 1) updating and modularizing objective-based classroom training courses for fire departments across the country; 2) creating a multi-player serious gaming DER incident simulator (the first of its kind—think flight simulator for pilots), and 3) developing a unique DER props guide for setting up the fire service field evolutions training (outdoor department training held at academy field settings). Together, these resources will provide emergency responders nationwide with engaging, innovative training and simulations on pre-planning DER installations, and effectively managing DER incidents. The result will be increased knowledge, greater levels of preparedness, and increased acceptance and promotion of DER technologies across the US.

Objectives

The objectives of this project are to research, develop, and deploy a suite of Distributed Energy Resources Safety Training (DERST) educational programs and tools for battery ESS, solar/PV systems, EVs and their charging infrastructure (EVSE), and building efficiency/retrofit technologies. NFPA will explore scenarios that consider the interaction of these technologies when encountered in the field. The DERST will be primarily targeted at firefighters, first responders, public safety officials, and other relevant emergency response professionals. In support of this objective, NFPA is currently working on:

1) Gathering the latest DER safety research and studies.
2) Conducting field testing, collecting data and best practices using the latest DER equipment and vehicles in controlled emergency fires and incidents.
3) Updating and modularizing our existing train-the-trainer programs for the fire service and emergency medical service (EMS) on ESS, PV, and EV/EVSE with both NFPA and Underwriters Laboratory's (UL) research, test results, and data, then distribute them across the country.
4) Creating a multi-user, role-based and scenario-based serious gaming platform for fire departments, based on the collected test result data, and training together on interactive, real-world, multiple DERs in the same structures (think flight simulator-style training for a team of firefighters).
5) Developing a DER field evolution prop guide for instruction and safety when conducting live DERST tactics training at any fire academy or outdoor training center and deploying it nationwide.

Approach

To achieve the goal for this 42-month project, NFPA detailed 11 tasks that supported successful completion of the established project objectives. See Table I.32.1, Project Approach.

Table I.32.1 Project Approach

Project Tasks	Description
Project Management and Planning	NFPA shall develop and maintain the Project Management Plan (PMP). The content, organization, and requirements for revision of the PMP are identified in the Federal Assistance Reporting Checklist and Instructions. The Recipient shall manage and implement the project in accordance with the PMP.
Kick-Off Meeting	NFPA will participate in a project kickoff meeting with the DOE within 30 days of project initiation.
16) Hold Partners Kickoff Meeting	Assemble partners and stakeholders for a kickoff meeting, determining issues, risks, responsibilities, rules, project schedule and milestones.
17) Conduct DER Fire Testing	Coordinate and conduct state-of-the-art incident testing DERs in controlled emergency fires and incidents. This testing will include burning an actual residential structure with multiple DER equipment involved in the fire (including PV, ESS, & EVSE). Uncover hazards and best practices for extinguishing the structure and DERs effectively and safety.
18) Collect the Latest DER Safety Research	Review and collect the latest DER literature, gathering up-to-date testing, tactics, codes & standards, regulations, and best practices to inform curriculum development.
19) Revise and Update Existing Train-The-Trainer Classroom Courses	Modularize and enhance the classroom training with the latest DER tactics.
20) Analyze and Document DER Fire Test Findings	Following the completion of the DER Fire Testing, the recipient will collect and synthesize all available data received from the burn testing.
21) Dissemination of Classroom Training Materials	DER safety classroom modules will be propagated across the country to all state and local fire training academies for their usage.

Project Tasks	Description
22) Onboarding of Serious Gaming Development Vendors	Issue a request for proposals for a qualified eLearning/instructional design team and development vendor.
23) Development of Serious Gaming DER Safety Simulator	Conceptualize and develop a multi-player, multi-role, multi-venue, multi-interconnected-DER incident gamified training tool.
24) Comprehensive Review of Gaming Simulator	Evaluate the Serious Gaming DER Safety Simulator from a scientific, technical, and responder tactic standpoint during a multi-tiered beta review process prior to delivery.
25) Field Evolution Activities and Props Guide Development	Conceptualize, design, and develop a unique guide to field evolution activities and prop selection that aids departments by setting up outdoor field evolutions at fire academies and training centers.
26) Field Evolution Activities and Props Guide Dissemination	Disseminate completed field evolution guide to state and local fire training academies through a nationwide outreach campaign.

Results

During the prior year's first phase of this project, on April 18, 2022, UT-Austin and the Austin Fire Department successfully conducted a residential house burn test with DERs (EV, EVSE, Solar, ESS) connected throughout the structure (Figure I.32.1). The objective of this burn was to collect and analyze data from each phase of the incident, starting with a 45-minute garage fire. The house had been wired with hundreds of sensors, video cameras and three drones monitoring the air, to measure the effect of the fire on the DERs and the residential garage structure during the blaze. The test also included studying the post incident firefighters' response to the scorched DERs, their elevated temperature, and their re-ignition potential.

The goal was to develop strategies for the fire service dealing with DER fires, update existing training with this new data, and recreate this scene in a virtual training environment during phase 2 of the project. UT Austin's burn test analysis showed that the ESS had arc flashed many times, as evidenced by the burn markings, and welded holes in the case. Also, it was observed that the ESS continued to burn long after the garage was extinguished. Further hose water was needed to cool the ESS and keep it from reigniting, as determined from a thermal imaging camera. Most of the EV was also consumed in the blaze, and all that remained was the metal shell of the vehicle and the battery case, bolted to the underneath of the frame. Surprisingly, the EV's battery itself did not become involved in the fire, due to its low position near the cooler cement garage floor (Figure I.32.2). Upon dissection of the battery case, the SMEs' opinion was that within an additional 10 to 15 minutes, heat intrusion into the batteries' case would have ignited the EV's batteries and added significant fuel to the existing fire. The fire was extinguished at the 45-minute mark to protect the surrounding neighborhood.

Figure I.32.1 Residential structure Distributed Energy Systems burn test

Figure I.32.2 Electric Vehicle and Energy Storage System after burn test

During the past year, NFPA continued to make substantial progress on the second phase of this project. Every other week, meetings with our subrecipient partners University of Texas, Austin (UT-Austin), the North American Fire Training Directors (NAFTD), Argonne National Laboratory (Argonne), and the team's fire service SMEs were held to provide channels of collaboration and establish learning points around responding to DER fires. UT-Ausin performed fire test analysis on the data gathered during the prior year's burn test and presented their findings to the team. NFPA's project team then assessed that information and developed a lessons learned document geared towards fire fighter potential tactics targeting DER fires. During that time, Underwriters Laboratories (UL) completed their testing of Energy Storage Systems (ESS) fires in the garage settings. As suggested and agreed upon by DOE, UL worked with NFPA to provide their latest research findings, pictures, and videos on their ESS burn tests, which are part of a parallel DOE Energy Storage Safety grant awarded to UL. These UL test results and meetings have enhanced NFPA's lessons learned document, which will be incorporated into the gamification and training, as the project team and UL continued to meet and refine the learning points. The development of the simulation environment became increasingly realistic, based on the final data and analysis, resulting in a more informed and therefore safer training curricula and gamification to be developed for the fire service (Figure I.32.3).

Figure I.32.3 Simulation environment of burn test for serious game

This past year, Emergency Training Solutions continued to update and modularized NFPA's existing Energy Storage, Solar, and Electric Vehicle Safety Classroom Training with the latest safety information, modularizing it for the Fire Service to be used more effectively during their onboarding efforts and/or regularly scheduled training classes. This classroom training update is on schedule to be completed by the end of 2023.

Also, during this period, UT-Austin and NFPA's SMEs conveyed the preliminary information to GHD Digital, NFPA's gamification vendor, which began implementing the serious game's learning points. GHD Digital then proceeded to use the Unreal engine as a platform to develop the serious game simulation training to recreate the Austin, Texas, residential structure DER fire (Figure I.1.3). Game play will be free form and involve an incident commander and multiple fire departments responding to a DER incident. The game is nearing completion by GHD Digital, as it is now in Alpha stage.

During the past year, NFPA provided GHD Digital with specifications for development of the serious game that included:

- Gamified real-world environments utilizing 3D modeling or other similar high-engagement, high resolution platforms.
- Simulated emergency incidents including smoke, fire, explosions, and other events fire fighters may encounter during a structure fire (Figure I.32.4).

Figure I.32.4 Serious game garage fire image

- A nonlinear instructional design approach that uses real-time game branching to challenge the user's comprehension, thus allowing for many possible performance outcomes during serious game play Figure I.32.5).
- A multi-user interface that allows for up to five simultaneous users filling commander roles to tackle the challenges as a team.
- In-program performance metrics for real- time assessment and feedback on performance.

- An interface that provides a desktop platform with detailed progress tracking.

Figure I.32.5 Serious game garage fire thermal imaging camera

GHD Digital has incorporated these specifications, the provided learning objectives, design blueprint, stakeholder requirements, and specifics regarding recommended instructional formats/methodologies for the program components into a scenario-based learning, gamified interactive immersive learning experience. They are currently in the process of releasing the alpha stage of this serious game training. This unique training will be tested by NAFTD and several fire departments in the fourth quarter of 2023.

Conclusions

During the past year, the following has been accomplished toward the project goals:

- NFPA's project team worked with UT-Austin and Underwriters Laboratories to analyze the collected burn test data from the prior year's residential fire test, and formulated a lessons learned and training goals document to build the serious game simulation around the modularized DER training.

- NFPA continued to work with Emergency Training Solutions to update and modularize NFPA's existing Energy Storage, Solar, and Electric Vehicle Safety Classroom Training with the latest safety information, modularizing it for the Fire Service to use more effectively in their existing training programs. This training is in its final stage of development and will be ready by the end of 2023.

- NFPA continued to work with GHD Digital to recreate the residential structure burn test in a fully immersive simulation environment (serious game) to instruct fire departments how to respond effectively to DER incidents. The serious game is currently being released in alpha stage, to identify inconsistencies, errors, and final refinements to the simulation before release.

I.33 Electric Vehicle Market Stimulation in Divested Economies (Metropolitan Energy Center)

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Start Date: March 1, 2022 End Date: February 28, 2026
Project Funding: $10,455,288 DOE share: $5,222,326 Non-DOE share: $5,232,962

Project Introduction

Electric Vehicles in Underserved Markets

Eight businesses and municipalities are managing cost-shared projects that operate within Kansas and Missouri environmental justice areas, opportunity zones, and other underserved areas to deploy electric vehicles (EVs) and charging stations. In addition to sedans, they are replacing small and heavy trucks with electric models. Thanks to generous 15% overmatch contributions from these eight funding recipients, this program will also fund a small grants program for underserved communities.

Small grant recipients will define for themselves what project features would be locally most beneficial, such as projects to install public EV charging stations in parking lots and at curbsides near multi-unit residential complexes and retail businesses. The success of the program depends upon placing EV charging stations within underserved or rural areas that feel the effects of environmental justice issues. Diesel emissions from heavy vehicles and off-road machinery contribute to early deaths, asthma rates and family illness, keeping people away from jobs and school. Those are just some of the health and social impacts from diesel fumes that affect the community members Metropolitan Energy Center (MEC) serves.

Objectives

The objective of this project is to expand the availability of EVs and charging at low cost in underserved urban and rural settings, with an emphasis on curbside and multifamily charging installations. Projects will reduce diesel fumes by supporting EV purchases, charging station installations, and outreach efforts to notify communities of these resources. The funds will also help small businesses and rural cities in Missouri and Kansas accelerate their transition to EVs.

Deployment equity matters, and one of the project's goals is to ensure availability of this EV charging network to residents, regardless of socio-economic or housing status. Lower income individuals and families could benefit the most from the long-term savings an inexpensive EV provides, yet they are least likely to have access to convenient, affordable charging networks. Geographic diversity is one part of unlocking the equity puzzle, and another is deployment in multi-family housing locations. A 2017 California draft study estimated installation costs of Level 2 charging for multi-family properties at an average price of $5,400, over triple the average cost for installation at a single-family residence. [1] Between 2006 and 2014, the percentage of Americans who rent rather than own rose from 36.1% to 41.1%. [2] With more people becoming renters, and residential electric vehicle supply equipment (EVSE) less attainable for renters, multifamily and curbside charging presents a more equitable solution.

Approach

Eight proposed subrecipients in the EV Market Stimulation in Divested Economies (EVMS-DE) project will deploy 38 EVs and install 40+ EVSE, directly impacting air quality in the identified Environmental Justice areas and Opportunity Zones. In addition, we will use the data generated to spotlight the project's impact on local residents, placing importance on their lived experience, including available local data that corroborates their anecdotes, coaching larger organizations through this increasingly popular innovative approach, namely businesses and municipalities that have historically looked past the lived experience of those without socio-political voice. This will involve contracting with local community-based organizations (CBOs) that will conduct outreach and engagement to local residents to understand lived experiences and gather data on preferences and needs, then working through the CBOs to identify landowners to host the charging stations. The data collected will inform target landowners and the final locations of the community charging stations under the small grants program. Additionally, our municipal subrecipients such as the City of Osawatomie will follow a similar approach. Post-deployment, we will collect data on usage and locations and compare it to the data collected during the outreach process and analyze its relationship to lived experiences voiced by community members. In MEC's experience, when an organization first tries out new technologies, initial projects tend to be much smaller in scope and cost than the projects of experienced project partners. The project's intent is to lower the barrier to entry for businesses and municipalities serving underserved communities, and to offset the historic exclusion of resources to the same communities. MEC requested a higher than customary cost share from initial project partner applicants (now our proposed subrecipients) and plans to utilize these cost-share overages to subsidize smaller projects generated from targeted engagement efforts in underserved communities, to restore healthy living environments through vehicle technology adoption.

Results

The City of Osawatomie, Kansas plans to deploy two EV Ford F-150s, two Ranger EV off-road utility task vehicles, and 16 public Level 2 EVSE at various locations throughout the city. The city held a ribbon cutting event on August 11, 2022, to celebrate the dedication of the location of their first (of ten planned) EV charging stations. The event was led by Osawatomie's Mayor and City Manager, with remarks by MEC and the State of Kansas Department of Wildlife and Parks. The event was covered by local media, including The Miami County Republic. The event is part of a larger effort by the City to go green and implement sustainability projects funded through this and other grants including an EV hub, bike racks, and walking trails.

The city held four public forums in the fourth quarter of 2022 and released a Request for Proposals (RFP) for charging stations early in Q4. Osawatomie has identified ten charging locations to MEC, and a National Environmental Policy Act (NEPA) Environmental Questionnaire has been submitted and approved by DOE. Their utility task vehicle (UTV) acquisitions are on track, but their Ford Lightning purchases are still up in the air. Their Enterprise representative for Ford has requested a meeting with them to clarify their intention to purchase these trucks.

Johnson County Community College (JCCC) plans to deploy eight EV and plug-in hybrid electric vehicles including one cargo van, one minivan, three sport utility vehicles (SUVs) and three pickup trucks in budget period 2. JCCC convened a committee to procure EV charging stations by July of 2023. Due to the supply chain issues other subrecipients have experienced in budget period 1, JCCC is reconsidering which fleet vehicles to replace.

Hirschbach Motor Lines has deployed a total of six EV terminal tractors and four charging stations in Olathe, Kansas, Edwardsville, Kansas, and Milan, Missouri. Hirschbach ordered the trucks from Orange EV. Hirschbach reports positive feedback from their clients and drivers on the vehicle's performance, emission reductions, and cost savings.

Kansas City Aviation Department (KCI) plans to deploy four EV shuttle buses at the airport. The buses will be used for transporting passengers from parking lots to the airport entrance. The buses are planned to use inductive charging pads while loading and unloading passengers. The inductive charging pads have been paid for from a different grant but will serve the vehicles under this grant. After a price spike in quotes provided by BYD in May raised concerns, KCI negotiated acceptable pricing during a visit to BYD in November 2022 and will proceed with the four-bus plan. Since the airport will be purchasing an additional three units outside the grant, BYD cut the prices quoted in May and the original goals of the project remain in place. Due to delayed price negotiations with BYD, buses are delayed and are projected to be delivered in first quarter 2024.

WaterOne is deploying nine EV Ford Lightning pickup trucks as maintenance vehicles. WaterOne submitted a purchase order for three F-150 Lightnings to Shawnee Mission Ford in August. WaterOne has received 2 Ford Lightnings and one E-Transit. See Figure I.33.1. Given higher pricing for EVs in general, the trim line for one of the three units has been changed to the base model to cut costs. Delivery time is currently unknown though Spring 2024 is possible. Two Level 2 chargers will be installed on-site, and additional charging stations will be installed in a new garage building, set for completion in late 2023 or early 2024. The charging stations are part of a different grant but will serve the trucks under this grant.

Figure I.33.1 Ford Lightning Truck, WaterOne

City of Lee's Summit, Missouri planned to deploy one Ford F-150 Lightning in the Public Works fleet. The city submitted a purchase order to Shawnee Mission Ford in August 2022 for acquisition of one Ford F-150 Lightning. The city noted in August 2022 that the original estimate of $39,974 increased to $43,641 since the City's original quote in June 2021. The city has had contractors conduct site evaluations at the Water Department building to get bids on the cost to install the planned charging station and developed a plan to pay for the increased cost. However, due to electric vehicle production delays and the City's perception of bad faith negotiations by Ford, the City determined to discontinue their work on the project.

Lazer Logistics manages yard operations, logistics and safety programs for the warehouse and distribution centers. Lazer Logistics originally planned to deploy 10 EV terminal tractors across three locations; however, they have since determined that two of their originally planned locations will not work out due to local regulations and plans. Lazer Logistics' deployments are complete in Sikeston, Missouri for one fast charger and two trucks. The Kansas City, Kansas site locations have changed and are currently undetermined. Lazer Spot is trying to identify replacement locations within disadvantaged communities (DACs). Lazer Spot is currently working on obtaining clearance to deploy the remaining four trucks at alternative sites and will propose these alternative sites to MEC once they are known. MEC was informed that the change in deployment sites was due to a closure at one location and unforeseen local regulations for on-road speed requirements at another location. Lazer Spot is evaluating new locations based on the project scope and guidelines for identifying underserved communities issued by MEC and DOE. All proposed locations will be reviewed and approved by MEC and DOE prior to final selection.

City of Ottawa, Kansas originally planned to deploy eight Level 2 EVSE and one DC Fast Charger (DCFC) at seven locations throughout the City; however, their contract was not executed due to concerns about their ability to execute. In Q3 2022 they sent a quarterly report stating that they were still negotiating the contract. They had been unresponsive to calls and emails since July 2022. MEC met with the City of Ottawa to discuss a path forward and the city determined not to proceed with the grant project Due to new National Electric Vehicle Infrastructure (NEVI) Formula Program requirements that the city was unaware of during the application phase, the city wants to ensure that their planned DCFC location will be aligned with the NEVI plans and requirements. The Kansas Department of Transportation (KDOT) will be informed of Ottawa's DCFC plans as part of our coordination efforts on the State's EV corridor planning.

Small Grants Program

In 2022, MEC started outreach to CBOs to conduct Community Listening Sessions in DACs as part of this program. Kansas City, Missouri has a strong neighborhood organization structure, so MEC identified groups within the DOE Environmental Justice DACs and contacted a subset of those groups. MEC modified the approach to identify CBOs that were expected to have greater capacity for participation in the project. MEC issued an RFP and broadcasted it to eligible CBOs serving underserved areas in the project's geographic scope. This RFP is for the community outreach stage of the project, prior to site selection. MEC will contract with CBOs in three to five target communities to identify high-priority locations for charging stations and conduct outreach to site hosts and the community. Due to delayed deployments, MEC determined to move forward with one target CBO at this time and issue another RFP for additional CBOs once more cost-share is available from the delayed subrecipient deployments, since the small grants program funding is dependent on that cost-share. MEC has executed the contract with our first CBO and held a meeting to begin work.

Lessons Learned

- Due to supply chain shortages associated with the COVID-19 pandemic, many subrecipients have received uncertain information from suppliers and it is possible that some equipment may be delayed and/or that subrecipients may incur increased costs because of inflation.

- Through this project we learned the importance of being willing to adapt. This year we experienced significant vehicle production delays which caused a sub-recipient to deobligate the contract we had agreed on. During our meeting, the sub-recipient informed us that they had determined that this opportunity was not right for their city. After an open discussion, we mutually agreed to discontinue the partnership and plan to reallocate the money to a different sub-recipient. We learned that every city has diverse needs and must prioritize projects accordingly, and those needs may not always align with our priorities. In the future, we will continue to have a solid line of communication with our sub-recipients and remain adaptable to changing conditions.

Conclusions

This project has encountered many unexpected challenges, but it remains on target thanks to the flexibility and persistence of the project partners. Although the project team is seeing delays due to the COVID-19 pandemic and other factors, project staff are monitoring opportunities to lessen these delays and are preparing mitigating actions as necessary.

References

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I.34 Affordable Mobility Platform (Forth)

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Start Date: August 1, 2022 End Date: December 31, 2025
Project Funding: $10,063,241 DOE share: $5,020,217 Non-DOE share: $5,043,024

Project Introduction

The goal of the Affordable Mobility Platform (AMP) Project is to reduce the barriers to mobility options and EV adoption facing underserved communities, particularly residents of affordable housing. The project will demonstrate that shared electric vehicles can be valuable, highly utilized, and self-sustaining community transportation assets that serve the needs of both employees and residents of affordable housing developments. AMP is a nationwide community carsharing program providing electric vehicles to affordable housing locations and low-income communities. Forth is working with local partners across eight U.S. states to increase access to clean transportation by making low-cost EVs available to underserved communities. AMP will create a replicable model for affordable housing agencies to adopt EVs and carsharing software as an equitable transportation service, as part of the agencies' established wraparound social services. In this model, agency staff can also leverage the EVs to increase efficiency and save on transportation costs. Thus, both agency staff and residents will receive economic, environmental, health, and mobility benefits from EV carsharing. Through collaborative project design with local agencies, refining the model through this demonstration project, and collecting data and sharing best practices, this model can easily be adopted by other agencies or nonprofits.

Objectives

The project aims to develop, demonstrate, and deploy a replicable model for expanding clean and affordable electrified transportation to underserved communities through plug-in electric vehicle (PEV) and electric vehicle infrastructure deployment, data analysis, education, and outreach that leverages real world data and lessons learned from project implementation in communities.

Project Objectives

- Increase access to clean, affordable transportation for residents of affordable housing developments.
- Demonstrate a replicable model for affordable housing providers to leverage shared vehicles and carsharing software to provide a mobility service to residents and decrease staff transportation expenses.
- Educate affordable housing fleet managers and employees about EVs, EV charging, carsharing, and the benefits associated with these technologies.
- Demonstrate how dual port EV chargers (with one port dedicated to a carshare vehicle and one port available to the public) can serve community members, effectively improving the regional charging network.

Project Outcomes

- Residents of at least 20 different affordable housing developments will experience increased access to affordable, convenient electric transportation and EV charging with a goal of at least 1000 individuals driving an EV for the first time through the AMP Project.

- At least 10 other affordable housing providers (beyond participants in the AMP program) adopt the model for their own residences.

- Service agencies build capacity to manage their new EV fleets, optimize charger usage, and reduce operating costs with at least one "EV Ambassador" at each site.

- The Cities of Portland, Oregon; Seattle, Washington; Boise, Idaho; Albuquerque, New Mexico; Las Vegas, Nevada; St. Louis, Missouri; Detroit, Michigan; and Charlotte, North Carolina experience increased awareness and adoption of EVs. Exact outcome measurement will be refined in Budget Period 2.

Forth has established several *Diversity, Equity, and Inclusion (DEI) SMART Milestones* to ensure the AMP Project is explicitly integrating DEI into its Project Management Plan.

- Report data on carsharing usage by low-income residents and residents who identify as persons of color.

- Recruit an EV Ambassador at each housing location to train other residents and promote the program.

- Hold workshops with residents at each housing site to co-design communications and educational materials and solicit project feedback.

- Black, Indigenous, and people of color (BIPOC) or women-owned and operated contractors perform at least 50% of EVSE installations.

Approach

Forth and its partners will be deploying shared electric vehicles in eight U.S. states in four regions (Northwest, Southwest, Midwest, and Southeast). Most project locations have been identified. View Figure I.34.1 for a map representing current AMP cities. Locations are subject to change.

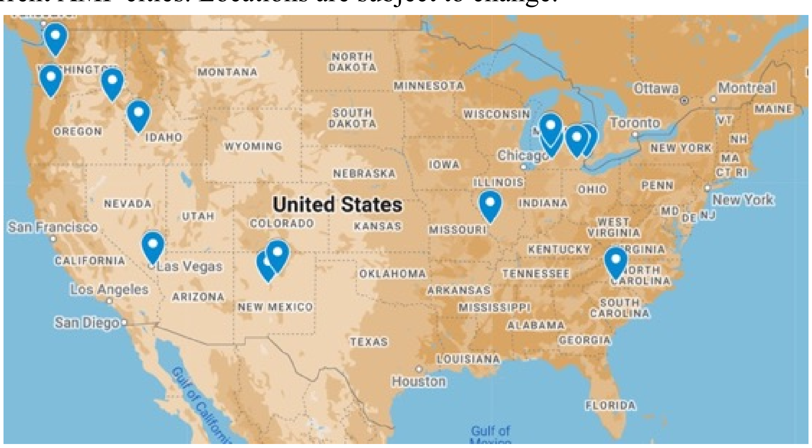

Figure I.34.1 Map of Likely AMP Project Cities

The project is broken up into three distinct budget periods:

- Budget Period 1: Project Development and Launch (August 1, 2022 - December 31, 2023)
- Budget Period 2: Operations & Refinement (January 1, 2024 - December 31, 2024)
- Budget Period 3: Operations, Technical Assistance & Dissemination (January 1, 2025 - December 31, 2025)

In the past year, Forth has conducted the following activities:

- Planning operations
- Finalizing agreements and contracts with partners and vendors
- Clarifying fleet requirements
- Modifying existing carsharing app to fit the project
- Establishing site locations
- Securing vehicles
- Sourcing and installing charging stations
- Preparing sites; staff training and education; data management planning and assessment.

To successfully implement the project Forth is partnering with over 40 subrecipients to deliver various components of the project. Subrecipients are broken up into seven primary roles, described in Table I.34.1.

Table I.34.1 Partner Types and Role Definitions

Partner Type	Role
Project Prime (Forth)	Lead overall project management, including partner management, community engagement, education/outreach, marketing, dissemination of findings and technical support, reporting, and complying with DOE guidelines.
Technical	Provide hardware and software for the project, including electric vehicle supply equipment (EVSE) hardware and network software, the carsharing telematic hardware and smartphone application and other general consulting support services.
Operator	Conduct the on-the-ground operations of carsharing services, including fleet management and member services.
Research	Support data collection and analysis and assist with report and case study production, specifically quantifying project impact.
Host Sites	Provide parking space for carshare vehicle, allow EVSE installation at their sites, promote program to residents, assist in program management and operations.
Support	Provide cost share, infrastructure support, site identification, marketing and promotion, and miscellaneous support as needed.
Dissemination	Present program results and learnings to Clean Cities Coalitions and other regional organizations.

Several deployment targets shape the AMP Project. View a list of deployment targets in Table I.34.2.

Table I.34.2 Deployment Targets for the AMP Project

Parameter	Total
Vehicles	
Number of Light Duty Plug-in Electric Vehicles (PEVs)	50
EVSE Infrastructure	
Number of New Level 2 Chargers	50
Number of Vehicle-Hours of Data Accumulated	≥5,000
Number of Vehicle Charging Events for Data	≥5,000
Number of Multi-Family Housing Chargers for Families with No Access to Street Parking	≥50
Number of Curbside Chargers for Families with No Access to Street Parking	≥3
Outreach	
Number of Education/Outreach/Workforce Training Events	17

Results

AMP is currently in phase 1, "Project Development and Launch"; therefore, vehicle and charging data collection has not yet begun. However, there has been significant progress toward the milestones established for this period. Tasks completed by the project team in the past year include:

- Submitted more than 40 National Environmental Policy Act (NEPA) reviews for partners and site hosts (a majority of which have now been approved).
- Coordinated more than 30 site walks by electricians to quote EV installations.
- Executed 14 host site agreements, which account for the placement of 18 vehicles and charging stations.
- Installed four chargers with a total of eight charging ports.
- Completed a Transportation Needs Assessment, which provides an overview of the demographics and transportation ecosystem for each project area.

Additionally, in September 2023, AMP was featured on PBS' *MotorWeek*, an award-winning automotive-focused television program broadcast to hundreds of stations across the U.S. with 429,000 direct subscribers.

Over the next several months, Forth and partners will install more charging stations, procure and onboard vehicles onto the carsharing platform, and go live with carsharing services.

Conclusions

While it is too early to draw conclusions on the objectives and outcomes of the AMP Project, key learnings and takeaways from the project development and launch phase are highlighted below.

- Contracting with the 40+ partners (including host sites) is taking longer than expected. For example, executing the contract with research partner Portland State University took a full year from initial meeting to contract signatures. Similarly, executing contracts with host sites has taken between six months to over a year, due to questions around risk, insurance, and other programmatic details, and several levels of bureaucracy within host organizations.

- EV infrastructure installations cost more than expected. While we originally estimated EV infrastructure installations would cost around $12,000 per site, across the 18 installation quotes we have received, the average is around $18,000. This has caused us to be pickier with our sites to keep costs down. Related, sites that require utility upgrades (such as a transformer) are not really an option, as the current wait period is said to be close to a year for this infrastructure and would not align with the project timeline.

- Vehicle and insurance procurement pose big barriers. Forth has struggled to work with its broker to secure a carsharing insurance policy for over a year, and a direct policy has yet to manifest. To overcome this, Forth contracted with Mobility Development to use their insurance policy to cover project vehicles. However, Mobility Development's insurance policy does not meet the requirements of many leasing underwriters, which meant that Forth could not procure vehicles through a traditional leasing company or dealership. (Forth negotiated with two leasing companies, Enterprise and Merchants Fleet, but the negotiations did not result in a solution with either company.) Forth now believes it has found a solution to the issue of vehicle and insurance procurement for the AMP Project, but this will remain a barrier for the carsharing industry.

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Creighton Randall, Richard Kosmacher, Mike Pletsch – Mobility Development
Amy Hillman, Jan Sommers – OpConnect

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Start Date: March 1, 2022 End Date: May 31, 2025
Project Funding: $13,868,484 DOE share: $6,666,667 Non-DOE share: $7,201,817

Project Introduction

The Upper Midwest Inter-Tribal Electric Vehicle (EV) Charging Community Network (Electric Nation), a Native-led public-private partnership addressing plug-in EV barriers for Tribal members, is working to provide equitable access to clean, affordable transportation in multi-family housing and rural, underserved Tribal communities. A core goal is to clearly establish for decision makers across public and private sectors that EV-based transportation will effectively lead to a green future, and investments in EV-related infrastructure are not only necessary, but also make good sense.

To increase public familiarity with clean transportation options and establish EV corridors from rural Reservations to key medical, educational, and retail destinations, the project has launched "Electric Nation" to:

- Deploy commercial, passenger, and transit EVs plus related equipment to test and demonstrate their potential.
- Catalyze energy self-determination and new job opportunities.
- Expand access to benefits of electrified transportation to more Tribal members.

The Minnesota Pollution Control Agency, Minnesota Power, Otter Tail Power, and Xcel Energy are providing support to electrify highways serving the region's Tribal communities. The project is adding EV chargers on frequently traveled routes from Standing Rock and Red Lake to critical destinations and along the Native American Scenic Byway.

Electric Nation is working to create a sustainable ecosystem to expand EV access by:

- Installing 59 DC fast charging units on Reservations and vital travel routes and installing 63 Level 2 electric vehicle supply equipment (EVSE) at community gathering spots, Tribal colleges, collocated with direct current fast chargers (DCFC), and other destinations.
- Deploying 16 light-duty EVs, an electric shuttle, and two electric school buses.

- Documenting energy savings, emissions reductions, and the impact on Tribal members created by this project and developing a pathway forward to a system free of fossil fuels.
- Developing two new workforce training programs for Red Lake and Standing Rock.
- Engaging in 52 events to engage and educate Tribal members, auto dealership sales staff, and first responders.

Objectives

The objectives of this Native-led public-private partnership project are to address plug-in EV barriers for Tribal members in the Upper Midwest and demonstrate EVs in Tribal communities, providing equitable access to clean, affordable transportation in multi-family housing and rural, underserved Tribal communities facing harsh winters. Through the installation of public and curbside charging infrastructure, this project is "connecting" Standing Rock Sioux Tribe, Red Lake Nation, and other Reservations with vital medical, retail, and government services in Minnesota, North Dakota, and South Dakota.

The project is deploying 19 commercial, residential, and transit EVs and related equipment (including 2 solar trailers for educational events and 3 freezer cubes for transporting Red Lake fish to markets) to test and demonstrate their potential on rural, cold-climate Reservations; catalyze energy self-determination and new job opportunities; and expand access to the benefits of electrified transportation to more Tribal members.

Leveraging public and private funds, this partnership is installing or upgrading 59 public EV charging hubs with DCFC infrastructure and 63 Level 2 EVSE, ensuring all 23 Native Nations in the three states have at least one Level 2 station. The partners are working to engage community members at 52 events over the project's three budget periods reaching more than 10,000 attendees. The project aims to lower the burden of transportation costs and provide access to advanced clean vehicles and infrastructure to Tribal community members disproportionately affected by transportation inequities.

Approach

Electric Nation founding partners working to catalyze energy self-determination and expand benefits of electrified transportation include Native Sun Community Power Development, SAGE Renewable Energy Power Authority, American Lung Association (ALA), Center for Energy and Environment, Connexus Capital, eFormative Options, and Minnesota and North Dakota Clean Cities coalitions. This project is building on these and other long-standing relationships and established regional partnerships to create an enduring local ecosystem increasing Tribal EV use across the Upper Midwest.

Electric Nation is demonstrating various EV applications in underserved Tribal communities by focusing on multiple sub-projects in the target three-state geographic area to determine suitable EV routes and strategies. The project is expanding the availability of EVSE, including innovative charging approaches for various settings, such as multi-family housing, school and public transit, and highway travel corridors. The project is also deploying light-, medium-, and heavy-duty EVs to test and demonstrate the different vehicle types in settings that may challenge currently available ranges and capabilities. Robust dissemination of experiences from this project is enabling other Tribes and communities to benefit.

Results

Project Launch & Engagement: The first Budget Period focused on determining locations of charging infrastructure and beginning installation. An assessment of current Tribal fleet vehicle uses informed the finalization of EVs to be purchased and their routes for deployment.

Project Implementation & Testing: During Budget Period 2, vehicles have been ordered and additional Level 2 charging infrastructure has been installed. See Table I.1.1 and Task 1.1 and 1.2, below, for details.
Analysis, Community Outreach & Reporting: Project partners have documented and shared experiences and lessons learned to inform future pathways to expanding electrification.

The project team has worked to connect Tribal nations with vital regional services and the clean energy economy as shown in Table I.35.1 through procuring and planning installations of new EV charging infrastructure; collecting usage information and other baseline data on fossil fuel-powered vehicles planned to be replaced by or used similarly to EVs to be deployed through the use of telematics; outlining key performance indicators for new EVs; developing messaging and promotional materials; and conducting education, outreach, and engagement. Some project outcomes have been slowed due to the COVID-19 pandemic and related supply chain delays, including charging station equipment shipping more slowly and more costly installation labor than previously expected.

Table I.35.1 Milestone Progress

Milestone	Description	Details
Level 2 Site Locations Finalized	All locations for publicly available Level 2 EVSE installations on Red Lake and Standing Rock Reservations determined	Red Lake Trading Post, Redby Community Center, and Ponemah Boys & Girls Club in MN; Sitting Bull College in ND; Grand River Casino and McLaughlin Cenex-Farmer's Union in SD
Vehicle Needs Assessment	All fleet participation confirmed	Native Sun, Red Lake Immersion School, Red Lake Fisheries, Red Lake Agricultural Department, Red Lake Family & Children Services, SAGE, Sitting Bull College Prairie Knights Casino, Grand River Casino and Resort, Standing Rock Sioux Tribe (SRST) Transit
Fleet Charging Preparation	All fleet locations evaluated to finalize plans for EVSE installations, with assessments completed	Underway; expected by May 2024
Fast Charging Locations	All site locations for Red Lake & Standing Rock DCFC evaluated for suitability	Red Lake National Children & Family Services Aldridge Location in Minneapolis, MN, Seven Clans Casino and Hotel, Redlake, MN; Sitting Bull College Transit Office, SRST Government Center, and Prairie Knights Casino, ND; Grand River Casino and Native American Scenic Byway (2), SD
Vehicle Purchases	Purchase orders for all project vehicles placed	2 school buses, 2 shuttle buses, 10 Ford F-150 Lightning EV pickups, 1 Ford Mach-e, 4 EV passenger cars
Level 2 Charging Installations	All planned publicly available Level 2 EVSE on Red Lake and Standing Rock Reservations installed and operational	Red Lake Trading Post, Sitting Bull College and Grand River Casino installed and online; Redby Community Center and Ponemah Boys & Girls Club expected end of 2023; McLaughlin Cenex-Farmer's Union expected early 2024
Safety Trainings	Safety training at both Red Lake and Standing Rock	Expected by May 2024
Go/No Go: Vehicle Deployment	All available vehicles in active service	Expected by May 2024

Task 1.0 – Project Management and Planning: Native Sun distributed a Request for Proposals for charging infrastructure equipment and installation in September 2023, with responses due October 16, 2023. The project team continued conducting monthly full team meetings, monthly meetings of the four work groups (with some flexibility of topics to ensure timely coverage), and monthly meetings of the Leadership Council.

All fleet agreements have been signed outlining expectations and responsibilities for fleets receiving electric vehicles. Native Sun secured purchase orders for 11 EV trucks and passenger cars. The team continued to work to complete remaining BP1 and BP2 milestones and monitoring the budget.

The team has worked to improve and streamline its project management to ensure everyone continues to work together successfully and smoothly. The team continues to explore opportunities to expand Electric Nation into additional states, and both Native Sun and SAGE are building capacity to be able to administer more funding.

Task 1.1 – Infrastructure: Bessler Electric installed the public Level 2 EVSE at the Red Lake Trading Post and provided an updated purchase order for charging station installation work at Redby and Ponemah, MN, scheduled for installation in late 2023. Edling Electric installed public Level 2 EVSE at Sitting Bull College and Grand River Casino. The third SRST site, a McLaughlin gas station, is planned for early 2024.

The team has continued monitoring supply chain delays impacting the project, including charging station equipment shipping more slowly than previously expected and limited supply of EVs. The team has continued working through details related to the physical installations, including site preparation.

The project team has been maintaining a tracking sheet to document details for 78 other new EVSE associated with the project being installed in MN, ND, and SD. The team has continued communications with project partners and utilities. Native Sun staff did a walkthrough at the Red Lake Fisheries to identify a location for its fleet charging station at the loading dock and has confirmed locations for other fleet EVSE.

Task 1.2 – Vehicle Deployment: The team specified orders for 10 F-150 Lightning trucks and one (1) Ford Mach-e and continued collecting fleet pricing options from additional passenger vehicle manufacturers for Red Lake Nation Children & Family Services.

Task 1.3 – Technology Development and Deployment: The team used data collected from existing Tribal fleet vehicles to support selection of appropriate EVs to meet individual fleet needs. In particular, the team considered miles traveled with existing gas/diesel fuel vehicles when identifying viable EV options. The team revised and updated its vehicle decision matrix with fleet priority weightings and additional criteria to select vehicles. The decision matrix helped narrow down manufacturers and dealers the team engaged with to obtain quotes. The team continued to work to resolve an issue with the Red Lake Ag Department's vehicle logger. The team created plans for gathering vehicle diary information.

Task 1.4 – Education, Outreach & Engagement: The team launched the project website, www.electricnation.info and finalized and uploaded Electric Nation's process document and style and usage guide to Dropbox. Team members discussed the project at events including:

- PI Blake spoke at Mobilizing Minnesota: Forging an Equitable Path to Electrification on March 22, 2023.
- PI Blake conducted an interview with BBC America in March 2023 for an upcoming documentary discussing Native Sun's impact on electrification of American Indian communities and his work.
- The team held two dealership trainings in Bismarck, ND, on June 2, 2023, one at Puklich Chevrolet to about 20 staff members and one at Cedric Theel Toyota to about 7 staff members. The team also met with staff at three additional dealerships on the afternoon of June 2 to have informal training

conversations. The team has reached out to eight dealerships in Bismarck and nine dealerships in Bemidji and northern Minnesota to attempt scheduling dealership trainings.

- The team held a ride-and-drive event at the SAGE Cannonball Run on June 3, 2023. About 16 individuals participated in the ride-and-drive. Four electric vehicle owners brought their vehicles for display. Three vehicles were available to test drive. Between the three vehicles, 21 test drives took place in total. The team collected pre and post survey data from test drive participants.
- PI Blake conducted an interview with Roadtrip Nation, where he discussed this project.
- PI Blake was a keynote speaker at the Affiliated Tribes of Northwest Indians Energy Summit on June 16, 2023.
- North Dakota Clean Cities staff presented the project at the City of Fargo Sustainability Committee on August 8, 2023. About 15 people attended the meeting.
- ALA hosted an EV showcase at the Red Lake Nation Embassy picnic on August 26, 2023.
- ALA staff hosted a climate community partner table including information about Electric Nation at the 2023 Minnesota State Fair Eco Experience building. ALA staff gave a presentation on this project at the Minnesota State Fair Eco Experience Sustainability Stage on August 28, 2023.
- PI Blake spoke on the Environmental Justice panel of the Clean Cities Stakeholder Summit on September 6, 2023.
- PI Blake presented the project at the RE+ conference in Las Vegas, Nevada on September 14, 2023.
- North Dakota Clean Cities had a booth at the North Dakota League of Cities conference on September 21, 2023, where staff discussed the project with roughly 75 attendees.

Figure I.35.1 Electric Nation Bookmark

The team updated its bookmark to hand out and continued to plan efforts for upcoming events, including pow-wows, more dealership trainings, and more ride-and-drive events. See Figure I.35.1.

Conclusions

Benefiting members and fleets of Standing Rock Sioux Tribe, Red Lake Nation and 21 additional Native Nations in Minnesota, North Dakota, and South Dakota, DOE funding is demystifying and increasing access to EVs and charging locations, enabling these communities to share EV economic and environmental advantages, reducing hesitancy for their use in cold climates.

Tribal communities continue to be receptive to the placement and use of EV charging stations and eager to drive EVs. See Figure I.35.2. Many Tribal departments have been quick to communicate and be active participants in planning EV purchases and have gained knowledge on EV and EVSE capabilities for fleet operations and impacts of cold weather on EVs and charging infrastructure. The team has confirmed viable EV options that can operate for the desired ranges in cold climates. Installing data loggers in vehicles has represented a professional development opportunity for the project team as well as fleet participants. The project team is also advancing workforce development opportunities for Tribal members in renewable energy infrastructure maintenance, including EV fleet maintenance and management.

Figure I.35.2 Charging stations with Electric Nation logo

Key Publications

The team recognizes the importance of documenting its challenges and solutions so that future renewable energy and climate projects can look to this project as a guide. Publicity and media coverage of the project has included:

- https://grist.org/fix/policy/23-predictions-for-2023-climate-justice-forecast-trends/
- https://insideclimatenews.org/news/20112022/three-midwestern-states-to-watch-as-they-navigate-equitable-rollout-for-ev-charging/
- https://www.canarymedia.com/articles/energy-equity/power-by-the-people-native-energy-sovereignty
- March 2023 Karunanews pushed Bob Blake's older interview through an aggregate to their audience: https://www.karunanews.org/story/5926/this-entrepreneur-is-bringing-solar-evs-and-jobs-to-his-reservation-and-beyond
- March 2023 SWCA published an article on SAGE, and approximately 23 paragraphs down the article talks about Native Sun and SAGE: https://www.swca.com/news/2023/03/winds-of-change-swca-assists-standing-rock-sioux-tribe-with-environmental-services-for

- March 2023 Red Lake Nation News aggregated a story about Native Sun: https://www.redlakenationnews.com/story/2023/03/03/news/red-lake-standing-rock-prepare-for-electric-vehicle-corridor/112347.html
- March 2023 Yahoo News: https://news.yahoo.com/red-lake-standing-rock-prepare-173958134.html
- March 2023 Native Roots Radio Wide Awake featured Bob Blake of Native Sun: https://www.am950radio.com/native-roots-radio-presents-im-awake-march-2-2023
- Bob Blake's NPR interview aired in September 2023: https://www.mprnews.org/story/2023/09/26/a-vision-for-green-energy-and-jobs-in-underserved-communities
- https://www.americanprogressaction.org/article/indigenous-owner-of-solar-power-business-says-inflation-reduction-act-is-game-changer/
- https://stories.xcelenergy.com/ArticlePage/?id=Solar-Rewards-brings-affordable--clean-energy-to-Minneapolis-non-profit--MIGIZI

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I.36 Equitable Mobility Powering Opportunities for Workplace Electrification Readiness (EMPOWER) (Columbia-Willamette Clean Cities Coalition)

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Start Date: April 1, 2022 End Date: June 30, 2025
Project Funding: $5,018,141 DOE share: $3,970,539 Non-DOE share: $1,047,602

Project Introduction

Reliable access to electric vehicle (EV) charging stations at home remains a barrier that prevents many drivers from owning a plug-in vehicle. Workplace charging can provide a pathway for plug-in ownership for those considering an EV and living in apartments, condominiums, or rented single-family homes, where access to reliable, onsite, overnight charging stations is severely limited. Workplace charging helps fill this gap and provides notable benefits to employers in the process by aiding workplaces in employee recruitment, retention, and elevating an organization's sustainability credibility.

The EMPOWER project is providing nationwide consistency for workplace charging resources, conducting valuable research to underscore the importance of these programs, creating a long-term communications framework, and supporting U.S. Department of Energy (DOE) Clean Cities Coalitions, utilities, and employers. The project addresses equity issues by increasing workplace charging access and benefits to minority communities, developing career pathways to the EV industry, and incorporating perspectives from diverse underserved communities at every level of project organization.

The EMPOWER team is led by Columbia-Willamette Clean Cities Coalition (CWCC). The project team is comprised of East Tennessee Clean Fuels (ETCF), assisting with contract and invoice management of the 30 partner Clean Cities coalitions conducting local outreach and coaching with workplaces; Cadeo, assisting with project resource development; Evette Ellis (formerly Geaux Green), creating the project statement of equity, inclusion, and diversity, along with equity training toolkit/webinars; Kimley Horn, assisting with project outreach resource development; ICF International (ICF), conducting literature and resources review; Center for Sustainable Energy (CSE), consulting on project evaluation, knowledge sharing, Clean Cities coalition implementation partner training resource development, and final project reporting; Smart Electric Power Alliance (SEPA) conducting utility outreach and engagement; and Cerritos College providing workforce training and development for engaged workplaces installing charging.

The project seeks to accelerate interest and support for workplace charging nationwide by leveraging Clean Cities coalitions to function as local coaches for workplaces and refer workplaces to a central resource website housing workplace charging tools, resources, and information. Local Clean Cities coalitions will simultaneously provide consistent messaging, tactics, and coordination with national data and utility partners. The project has a primary goal of advancing employer pledges for workplace charging programs and installations. Secondary goals include collecting and advancing electric vehicle charging research and increasing career pathways in the EV charging industry for underrepresented communities.

Objectives

The proposed project tasks for Budget Period 2 feature a mix of outreach and implementation work, along with constant project refinement. The tasks in Budget Period 2 represent these processes for engagement, implementation, and refinement of the EMPOWER project. The project team has established detailed outreach plans, launched a web platform with a variety of publicly accessible workplace charging resources, launched successfully into the workplace engagement phase of the project, and created a feedback loop with partner Clean Cities to share blockers and barriers with project leadership for continual refinement. Such refinement is also a product of the project evaluation being carried out by project partner CSE.

Success during Budget Period 2 will include evaluating and improving the outreach program based on feedback from Clean Cities Implementation Partners, engaging employers, utilities, and workforce development partners, and delivering a technical presentation at the Vehicle Technologies Office Annual Merit Review meeting. A more detailed summary of Objectives for Budget Period 2 includes the following:

1. Targeted Outreach limited test completed.
2. Evaluation of outreach test completed.
3. Targeted Outreach campaign launched.
4. National Workplace Charging Working Group meeting held.
5. First project evaluation conducted.
6. Over 10 utilities engaged through utility working group calls.
7. Technical presentation at the Vehicle Technologies Office (VTO) Annual Merit Review meeting held in Washington, DC.
8. Workforce development training event held.
9. More than 2,000 employer organizations engaged to support or advance workplace charging programming.
10. Outreach plan completed for broadly disseminating the project approach and learnings such that other communities can replicate project successes.

Approach

The project will continue to provide resources and support to workplaces in overcoming barriers to installation of workplace charging. The project team will provide data-informed marketing materials, ease of resource sharing, employer engagement, training classes, and recognition for workplace pledges to install workplace charging. The project goals are to engage 2,000 workplaces, secure 650 pledges from workplaces to increase EV access for their employees, and realize 3,500 charger ports installed at workplaces nationwide, with 40% of all project accomplishments coming from historically disinvested or pollution over-burdened communities. So far, the project has exceeded its goal to engage 2,000 workplaces and direct over 40% of all project benefits to communities which align with these equity goals, mirroring the goals of the White House's Justice40 Initiative.

CWCC will continue to meet these goals by leveraging the project resources with the existing community relationships of 30 Clean Cities coalitions functioning as local coaches for workplaces, known formally as the project's Implementation Partners. The project team has started implementation on time and will continue with the timeline outlined in the Project Management Plan.

The project's Implementation Partners in the form of 30 U.S. DOE Clean Cities coalitions are a core facet of the program to engage with these communities nationwide. They represent the largest assemblage of Clean Cities coalitions on a single VTO grant in VTO's history. These local partners have established relationships, with over 30 years of experience in their respective communities. They are the local experts in helping their stakeholders address fundamental barriers to adopting cleaner fuels and technologies, including workplace charging. Clean Cities coalitions will leverage resources, materials, and guidance from the EMPOWER team to foster relationships with local workplaces and help these stakeholders throughout the entire process to successfully install workplace chargers under the EMPOWER project.

Clean Cities coalitions provided their final lists of workplaces to engage during the Implementation Phase of the project by conducting outreach to workplaces. Coalitions also provided the project team with individual Outreach Plans which were shared with ICF and compiled into a single project-wide Outreach & Dissemination Plan.

Cadeo produced a Market Barriers Report literature review summarizing barriers to workplace charging, and ICF developed a literature review summarizing best practices for recognition, which will directly inform the project's workplace recognition plans, which aim to increase workplace charging adoption by formally recognizing the community leadership of employers that provide EV charging for employees. The program has been fully developed and is set to launch later in Budget Period 2.

Regarding internal and external outreach, the project has hosted multiple virtual utility workplace charging workshops with SEPA and will similarly host a virtual equity training with project partner Evette Ellis (formerly Geaux Green).

The EMPOWER team has developed outreach resources for Clean Cities coalitions and other public workplace charging resources and has hosted them on the project's web-based landing page, workplacecharging.com. The website has undergone a redesign based on partner feedback and the redesign is set to launch in October 2023.

Results

The project has made strong progress on the milestones and deliverables outlined in the Statement of Project Objectives (SOPO) and the original Technical Volume).

- So far, the EMPOWER project has engaged 2,250 total workplaces, exceeding the project goal of 2,000 workplaces. Of the engaged workplaces, 100 have signed pledges to commit to exploring EV charging for their workplace, 47% of which qualify as Energy and Environmental Justice (EEJ) workplaces. The project has also logged a total of four workplace charging installations representing 10 installed charging ports.

- CWCC kicked off project implementation activities ahead of schedule in early January 2023. The project team hosted two in-depth workshops in January to kickstart the coalition activities for EMPOWER outreach, and to educate coalition members on important implementation procedures. The project also held Regional Captains meetings to facilitate communication between different regions while ensuring all coalitions receive adequate implementation training.

- All Clean Cities coalition contracts were finalized in the first quarter of Budget Period 1, and CWCC has developed monthly progress reports, invoicing templates, and Key Performance Indicator reporting methods for subrecipients to complete when submitting invoices as a tracking and feedback mechanism for CWCC and has continued to improve on these tracking and reporting practices.

- New Clean Cities coalitions were also added to the project: Clean Fuels Ohio and Greater Washington Region Clean Cities Coalition.

- The project team and CSE finalized the Evaluation Plan and began the first phase of evaluation, starting January 18, 2023. Evaluation is ongoing throughout the project and will focus on improving the efforts of EMPOWER as needed. Evaluation topics include data collection from coalition members about outreach, and feedback on user experience related to the EMPOWER's website resources, and from disadvantaged workplaces about overall equity and inclusivity of the project.
- CWCC hosted and led the first Strategic Advisory Team meeting and initiated the first meeting of the Review Team on February 8, 2023.
- On February 28, 2023, the project team launched the EMPOWER Workplace Charging Resource Center on www.workplacecharging.com, a site owned and hosted by Shift2Electric. The website provides resources and tools for the Clean Cities coalitions to utilize during implementation and outreach to workplaces about workplace charging. These include an employer survey, workplace charging one-pagers for employees, an EMPOWER one-pager, an FAQ section, and material on the health benefits of electric vehicles provided by the American Lung Association. As part of CWCC's evaluation of the Targeted Outreach Test, the project team kicked off work on updating the EMPOWER workplace charging website. Significant progress was made to update the site in line with feedback received from project partners since launch. The progress made will allow for a planned website relaunch in October.
- CWCC hosted an all-partner in person meeting at their Green Transportation Summit and Expo (GTSE) conference. EMPOWER partner organizations and Clean Cities coalitions from across the country attended to collaborate and align on project focuses for the next Budget Period of the EMPOWER program. Project partners shared key feedback at this time from the project's targeted outreach campaign to help CWCC fine-tune outreach for the extended campaign.
- As a part of CWCC's evaluation of the Targeted Outreach Test, CWCC received feedback from project partners on the workplace charging commitment letter. CWCC revised the letter, shifting its name from a "commitment letter" to a "pledge letter" while simplifying the language in the process.
- The project team has finalized the EEJ Action Plan, Metrics and Toolkit package, a major component of the EMPOWER project which was developed under the EEJ Team's direction with input from key equity experts. The new Argonne National Laboratory Energy Justice Dashboard was identified as the main mapping tool for identifying disadvantaged communities to meet EMPOWER's EEJ Metrics.
- CWCC is one of three concurrent DOE-funded workplace charging projects. CWCC hosted and attended regular monthly planning meetings with the other two DOE-funded workplace charging projects led by Forth Mobility and CALSTART. These meetings were facilitated by ICF, which is funded by CWCC and the EMPOWER project for this tri-project collaboration and coordination work. Meetings in the planning stage were focused primarily on coordinating efforts to reduce duplication or redundancy in workplace outreach, including data management, website development, and coordinating the unique outreach focuses of each project. Current discussions have centered on outreach and EEJ action plans, marketing packages, and continuing to coordinate unique outreach focuses for each project.

A complete summary of project accomplishments and remaining work can be found in Table I.36.1.

Table I.36.1 Project Milestones Log

BUDGET PERIOD 1 (April 2022 – June 2023)				
Date	**Result**	**Source**	**Description**	**Status**
July 30, 2022	Deliverable	TV*	Project Management Plan completed	Complete
Rescheduled from July 30, 2022 to Feb 28, 2023	Output	TV	Communications and Reporting Plan completed	Complete
Rescheduled from August 1, 2022 to Jan 25, 2023	Output	TV	Contracts finalized	Complete
August 17, 2022	Output	TV	In-person meeting held	Complete
September 15, 2022	Output	TV	Regional Captain Kick-off Call held	Complete
September 20, 2022	Output	SOPO**	Employer interest evaluation plan completed	Complete
September 15, 2022	Technical	TV	First meeting of Strategic Advisory Team	Complete
September 30, 2022	Output	TV	Project Schedule finalized	Complete
November 1, 2022	Output	Other	EEJ Metrics defined	Complete
Rescheduled from November 30, 2022 to March 15, 2023	Deliverable	TV	Literature Review completed (Cadeo)	Complete
Rescheduled from December 1, 2022 to March 30, 2023	Deliverable	TV	Marketing Plan completed	Complete
Jan 1, 2023	Deliverable	TV	Project Partner Equity Toolkit completed	Complete
Jan 30, 2023	Output	TV	Data Intake Template completed	Complete
Feb 28, 2023	Deliverable	SOPO	Workplace Charging Resource Center (WCRC, an online platform) launched and available to the public	Complete
Rescheduled from March 15, 2023 to May 15, 2023	Output	SOPO	Health and environmental benefits information released on website	Complete
March 30, 2023	Deliverable	SOPO	Final list of employer organizations completed	Complete
June 1, 2023	Go/No-go	SOPO	Outreach plan for broadly disseminating the project approach and learnings such that other communities can replicate project successes completed	Complete

BUDGET PERIOD 2 (July 2023 – June 2024)				
Date	**Result**	**Source**	**Description**	**Status**
Rescheduled from July 1, 2023 to August 31, 2023	Output	TV	Targeted Outreach Limited Test	Complete
Rescheduled from August 10, 2023 to September 29, 2023	Output	TV	Evaluation of outreach test	Complete
Rescheduled from September 23, 2023 to October 13, 2023	Output	TV	Targeted Outreach Campaign Launched	Complete
December 1, 2023	Output	SOPO	National Workplace Charging Working Group meeting held	In progress
Jan 1, 2024	Deliverable	TV	Project evaluation (first) conducted	In progress
April 1, 2024	Output	SOPO	More than 10 utilities engaged through utility working group calls	In progress
May 1, 2024	Deliverable	SOPO	A technical presentation at the Vehicle Technologies Annual Merit Review Meeting held in Washington, DC.	In progress
June 1, 2024	Output	SOPO	Workforce development training event held	In progress
June 1, 2024	Output	SOPO	More than 2,000 employer organizations engaged to support or advance workplace charging programming	Complete
June 15, 2024	Go/No-go	SOPO	Outreach plan for broadly disseminating the project approach and learnings such that other communities can replicate project successes completed.	In progress

*Technical Volume
**Statement of Project Objectives

Conclusions

Overall, the project is moving forward consistently and making good progress. The project successfully met all Budget Period 1 Technical Milestones and Go/No-Go Milestones and is on-track to meet similar milestones outlined for Budget Period 2 in the Statement of Project Objectives.

As of September 30, 2023, all project objectives are on track for completion by the end of Budget Period 2, including the Go/No-Go Milestone for a project-wide Outreach Plan for broadly disseminating the project approach and learnings such that other communities can replicate successful projects.

The project is also in good financial standing. The project team expects to complete the required scope of work on schedule and within the provided budget amounts.

I.37 Charge@Work (Charge to Work USA) – (CALSTART)

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Start Date: April 1, 2022 End Date: June 30, 2025
Project Funding: $5,040,747 DOE share: $3,999,994 Non-DOE share: $1,040,753

Project Introduction

As electric vehicle (EV) options expand to meet more drivers' transportation needs, access to reliable, convenient, and affordable charging is a paramount determinant of EV adoption. With EVs recently surpassing 5% of new car sales nationwide [1], more charging facilities will be necessary to support mass market levels of EV adoption by 2030. In much of the country, workplaces centrally host vehicles for eight or more hours on working days, which presents immense opportunity to support large-scale EV adoption through the addition of charging stations to office parking lots.

However, the effort, time, cost, and challenge of installing EV charging makes workplace charging (WPC) an uncertain proposition for employers. WPC does not always present employers with a business case in terms of revenue generation, employee satisfaction and retention, or sales growth. Many employers are also not well informed on the options for and benefits of implementing a workplace charging program and will need education and some degree of consulting before they are ready to make a commitment to a WPC program. This may require customization and analysis of third-party service options, based on the workforce, facility, and owner preferences and constraints.

Charge@Work (Charge to Work USA) aims to create a self-sustaining national market for WPC, spur greater EV adoption by enhancing driver confidence in charger availability, and expand access to electric mobility in disadvantaged communities. A national EV workplace charging program can provide the awareness, education and technical assistance needed to help employers understand the technology and its benefits. There are multiple tiers of beneficiaries, including the business, employees, the environment, and our economy. Charge@Work galvanizes greater interest among electric vehicle supply equipment (EVSE) vendors, who until now have perceived WPC projects as low-return undertakings. These vendors thus welcome a means to funnel employers of all types into an intuitive, streamlined and highly automated platform that reduces soft and hard costs, including consulting, planning, and implementation time and effort. Charge@Work will significantly reduce costs for all stakeholders in the process (including customer acquisition costs for vendors), spur installation of convenient EVSE at places of business, and ultimately animate greater EV adoption.

Objectives

The objective of Charge@Work is to develop and execute a nationwide workplace charging program comprised of education, outreach and technical assistance activities that enables a large-scale increase in WPC. The project will gain more than 1,000 employer commitments (100 of which will be from large employers) to adopt WPC programs and install charging ports at their workplaces, with the end goal of catalyzing more than 100,000 EVSE port installations in total.

Approach

Charge@Work will reshape workplaces nationwide into charging hubs for electric commutes through a multipronged strategy based upon the following pillars:

- Launching a public influence and recognition campaign in partnership with supportive public officials.
- Conducting outreach and education to employers throughout the country, focusing on large national employers to lead high-volume WPC implementation.
- Providing technical implementation assistance for private and public sector employers to help identify and select EVSE and support installation with complimentary site assessments.
- Developing and disseminating resources to assist employees in advocating for WPC.

Influence and Recognition Campaign: In partnership with the Climate Group's Under2 Coalition and additional sustainability networks of elected leaders across the United States, CALSTART aims to secure endorsements of the Charge@Work program from at least 200 public/elected officials. Charge@Work is developing and implementing a national campaign to engage public officials who are committed to transportation electrification, and to support them by working with EVNoire and Clean Cities coalitions in strategic locations of the country to host workplace charging rallies and showcase events. Project partner Northeast States for Coordinated Air Use Management (NESCAUM) will compile case studies for at least eight exemplary WPC programs spanning a diverse range of employer types.

Employer Recruitment: Charge@Work aims to recruit a total of 1,000 employers to commit to WPC by signing the Charge@Work pledge. Our team will generate social and earned media to recruit diverse employers to participate in the campaign. Participants that sign the Charge@Work employer pledge will qualify for tailored technical assistance with implementing a WPC program. The project team will emphasize enterprise-wide commitments from large employers (>500 employees) by leveraging major corporate sustainability networks such as the EV100 campaign convened by the Climate Group. In total, Charge@Work will recruit a minimum of 100 large employers to account for the bulk of the 100,000 EVSE port commitment target, supplemented by smaller port commitments from 900 small (≤50) and midsize (51-500) employers (see Table I.37.1).

Table I.37.1 Annual Program Targets for Employer Recruitment

Employer Size (# Employees)	Large (>500)	Medium (51-500)	Small (1-50)
Budget Period 1	10	25	75
Budget Period 2	40	75	225
Budget Period 3	50	125	375
Total	100	225	675

Technical Implementation Assistance: Our team will design, develop, operate, and maintain an online Workplace Charging Resource Center (WCRC) to function as a centralized resource hub for workplace charging information and implementation nationally. This platform will provide customized WPC resources for employers, employees, municipalities, and industry, and enable WCRC visitors to request ride-and-drive events. The WCRC will include a dedicated Project Builder tool to walk employers through EVSE implementation, including EVSE comparison, site assessment and planning, and financial projections.

Data Collection and Analysis: The Charge@Work team will collect and analyze data to measure the internal and external performance of the Charge@Work program, and to understand how best to educate and motivate employers and assist them as they commit to and implement WPC programs. The team will undertake data collection and analysis to monitor internal performance including efforts to effectively lead, control and continuously improve WPC campaign efforts. Further, the team will empirically observe external performance and market conditions, such as the evolution of EV consumer perception and knowledge, the change in EVSE equipment, installation, and customer acquisition costs over time, and the effectiveness of WPC efforts in catalyzing EV adoption and EVSE utilization. Data collection and reporting will cover multiple aspects of program performance including technical and cost data from installations, geographic progress in implementing WPC programs, behavioral and planning data about employers and employees, data about WPC program decisions by employers, and data from EV charger operations.

The project will be conducted across three budget periods:

Lay the Foundation for Workplace Charging Nationwide (Budget Period 1):

During the first budget period, we prioritized coordination with fellow WPC grantees to develop a Charge@Work brand and associated collateral. We will continue to develop the WCRC, a program website that will contain WPC resources such as best practices guides, case studies, and employee advocacy materials, as well as a Project Builder where employers can receive tailored technical assistance to streamline WPC selection, planning, and execution. We developed initial versions of the Employer Recruitment Strategy, Data Collection Plan, and Outreach/Dissemination Plan, and began work with partners to obtain commitments and endorsements from large employers and public officials alike. We planned for multiple influence campaign events featuring supportive officials and businesses, some of which will feature ride-and-drives to promote EV awareness among employees and the general public.

Gain Momentum in Workplace Charging Implementation (Budget Period 2):

In the second budget period, our team will emphasize large-scale employer recruitment and provision of extensive technical assistance through the online Project Builder tool. We will continue to convene workplace charging rallies and other public events with public officials to promote WPC, showcase leading employers, and prepare written case studies to profile exemplary employers. We presented program progress and preliminary/interim results at the Vehicle Technologies Office’s June 2023 Annual Merit Review. We are beginning to develop a white paper describing best practices for utility programs to support workplace charging. We continued to update the Employer Recruitment Strategy, Data Collection Plan, and Outreach/Dissemination Plans.

Create a Self-Sustaining Market for Workplace Charging (Budget Period 3):

In the third budget period, our team will continue to conduct employer recruitment and to provide technical assistance through the online Project Builder, with emphasis on completing as many EVSE installations as possible before the project period expires. We will develop a funding model to sustain the operation and maintenance of the WCRC following the conclusion of the grant. We will continue to convene workplace charging rallies and other public events with public officials to promote WPC and showcase leading employers and prepare additional written case studies to profile exemplary employers. We will present on program progress and preliminary/interim results at the Vehicle Technologies Office’s Annual Merit Review. We will finalize and publish the white paper describing best practices for utility programs to support workplace charging. We will make final updates to the Employer Recruitment Strategy, Data Collection Plan, and Outreach/Dissemination Plans and complete a final report for the program.

Results

Outreach and Influence Campaign

The Charge@Work team focused heavily on the development of the outreach and influence campaign. Our team met with close to 200 local and national employers, public officials, metropolitan planning organizations (MPOs), planning departments, state agencies, and municipalities to share information about the program and technical assistance offerings. Through our CALSTART member network and regional partners, we hosted webinars and presented Charge@Work to industry and regional audiences. These webinars were hosted in collaboration with our Charge@Work subrecipients, EVNoire, Climate Group, Save Energy Coalition, and

Pittsburgh Region Clean Cities. See Table I.37.2. These outreach efforts allowed our team to secure employer and public official pledges, most noticeably in Budget Period 2.

Table I.37.2 Charge@Work Webinars and Presentations

Title	Date
Climate Action Summit Presentation	April 23, 2023
CALSTART Member Webinar	May 31, 2023
EVNoire Member Webinar	July 20, 2023
Virginia Energy Purchasing Governmental Association (VEPGA) Webinar	August 9, 2023
Garfield County EV Focus Group	September 8, 2023
Save Energy Coalition Webinar	September 26, 2023
Pittsburgh Region Clean Cities Event	September 27, 2023
Roanoke Valley-Alleghany Regional Commission Presentation	September 28, 2023
Smart Columbus Webinar	September 28, 2023

Table I.37.3 Charge@Work Pledges

Charge@Work Pledges	Employers	Public Officials
Budget Period 1	4	6
Budget Period 2	40	23
Total	44	29

The number of pledges displayed in Table I.37.3 is an aggregate of pledges attributed to CALSTART and Forth. CALSTART and Forth are working together to advance workplace charging across the U.S. by co-promoting and jointly raising the profile of the Charge@Work program.

Diversity, Equity, and Inclusion (DEI) Outreach and Analysis

To meet Charge@Work's Justice40 goals, our team has conducted research to determine which of our current pledges are in underserved communities and where we should focus future efforts. These metrics were determined by using the Justice40 tool published by the Biden administration and Department of Transportation. The results show that 14% of Charge@Work pledge signatories are located directly in Justice40 communities, while over 34% are census tract adjacent. In total, the amount of served, or potentially served Justice40 communities through our program is over 48% of all pledges. See Figure I.37.1. Though not directly located within Justice40 tracts, the adjacent locations are a key metric to analyze. For a location to qualify as "Justice40 adjacent", it must either share a direct border with a Justice40 community or be surrounded by, and easily accessible to Justice40 tracts. There is a reasonable ability for Justice40 communities to work and commute to these adjacent locations, where they can engage with workplace charging.

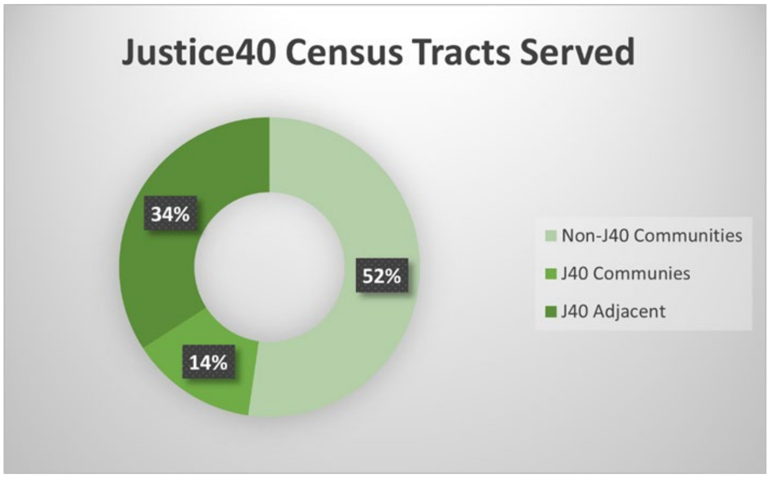

Figure I.37.1 J40 Mapping Tool (USDOT, 2021)

Workplace Charging Resource Center and Project Builder Development

The Charge@Work WCRC and Project Builder tool were built out and improved upon across multiple iterations with support from Aside and Zappy Ride. In the Spring of 2023, CALSTART launched the WCRC landing page and resource center. Through summer 2023, CALSTART added the Charge@Work pledge to the WCRC and Zappy Ride began development of the Project Builder tool. As of September 2023, CALSTART has updated the WCRC with a News & Events page to highlight press releases, webinars, and workplace charging rallies. In addition to the News & Events page, CALSTART added an About page to walk site visitors through basic program background and visualize our process.

The Project Builder tool will go hand in hand with the technical assistance offered by the Charge@Work team and will allow employers to build a customized WPC plan that is specific to their sites. The Project Builder will include a charger catalogue, cost estimates, an incentive program database, and a project management tool that streamlines the installation process. Through the Project Builder tool, Charge@Work will also offer free site assessments through QMerit and ChargePoint, which will allow employers to better understand the constraints of their sites.

Conclusions

Charge@Work has made significant progress toward our program goals and objectives, most notably in outreach and development of the WCRC. Through outreach, the project team has gained valuable knowledge that has guided our outreach strategy and future efforts. To initiate outreach through Charge@Work's large national scope, the team has worked alongside CALSTART staff and program subrecipients to identify specific stakeholder groups that may benefit from Charge@Work offerings and/or support the influence campaign. These groups include member networks, MPOs, municipalities, planning agencies, local universities, and commercial real estate firms. In addition to our individual outreach, we have adopted a "top of funnel" outreach strategy that targets large networks to increase the conversion rate of pledge signatories.

In conducting outreach to these specific stakeholder groups, Charge@Work has gained valuable insight into outreach conversion rates and the amount of time necessary to develop relationships that lead to meaningful impact and implementation. As Charge@Work continues to increase the volume of outreach and technical assistance, the program will collect statistically significant data that can be extrapolated to future programs and inform outreach and technical assistance strategies and program designs for years to come.

Key Publications

Program Website: Charge@Work — Powering Workplace Charging (chargeatwork.org)

Charge@Work Service Offerings One Pager: Charge@Work OnePager.pdf

Charge@Work About Us Video: About Us Video

New Jersey Department of Environmental Protection Press Release: NJDEP Press Release

Santa Fe Climate Matters Radio Interview: Santa Fe Radio Interview

City of Santa Fe Press Release: City of Santa Fe Press Release

Government Technology Article: GovTech Article

Save Energy Coalition Webinar: Save Energy Coalition Webinar

References

[1] https://www.greencarreports.com/news/1137003_ev-sales-crack-15-of-vehicle-market-in-california-tesla-continues-to-dominate

Acknowledgements

CALSTART acknowledges the partnership of the full Charge@Work team, which includes EVNoire, the Climate Group, NESCAUM, ZappyRide, Qmerit, National Grid, Edison Electric Institute, Empire Clean Cities, Eastern Pennsylvania Alliance for Clean Transportation, Pittsburgh Region Clean Cities, Drive Clean Colorado, Land of Sky Clean Vehicles Coalition, and Save Energy Coalition. We would like to express gratitude for the support and guidance we have received for this grant from our NETL program manager, Brett Aristegui, and contract administrator, Maureen Davison. We also acknowledge the productive collaboration and coordination we have enjoyed with companion teams, LEEP (led by Forth) and EMPOWER (led by Columbia-Willamette Clean Cities), which were funded in parallel by DOE from the same area of interest.

I.38 Project Sila: An Arctic CNG Pilot Test Program

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Start Date: March 11, 2022 End Date: May 31, 2025
Project Funding: $2,128,154 DOE share: $1,064,076 Non-DOE share: $1,064,078

Project Introduction

The overall objective of this project is to successfully demonstrate how compressed natural gas (CNG) vehicles can reduce greenhouse gas emissions and be adopted at a larger scale across the Prudhoe Bay oilfield. ASRC Consulting & Environmental Services, LLC (ACES) will purchase two CNG heavy-duty (Class 8) trucks fitted to serve the Deadhorse, Alaska area in water and liquid waste hauling. To support these trucks, a CNG compressor and a fueling station will be procured and installed at the ASRC Energy Services (AES) fleet and maintenance facility in Deadhorse. AES will operate and maintain the vehicles and the refueling station. AES will collect data from these activities on performance, costs, and emissions to demonstrate the advantages of CNG operations in remote, arctic locations. This project commenced in March 2022 with anticipated completion in June of 2025. If successful, this may result in a nearly 40% reduction in greenhouse gas emissions and lower operating costs for the Deadhorse and Prudhoe Bay area.

The goals for Budget Period 1 are to purchase two CNG heavy-duty trucks and modify them for arctic operation as well as install a CNG compressor and fueling station at AES facilities in Deadhorse. As described below, both trucks have been ordered but are experiencing delivery delays. The CNG compression and fueling equipment was also selected and ordered, with delivery to Anchorage, Alaska anticipated for mid-October 2023.

Objectives

The primary objective of this study is to prove CNG trucks can operate in the arctic using a readily available fuel source that is more economical and reduces greenhouse gas emissions. After the initial pilot study is complete ACES believes CNG will be adopted at a greater scale across the North Slope utilizing an expanded fleet of CNG powered vehicles. Since the start of this project, several other North Slope operators have expressed interest in the potential for CNG fleet applications.

To achieve these objectives ACES will select and procure the necessary equipment in Budget Period 1; install, implement, and monitor the CNG compressors, fill station, and trucks in Budget Period 2; and continue implementation and monitoring in Budget Period 3.

Approach

AES will introduce two vocational CNG trucks into its existing fleet of equipment in 2023. AES will train operators and adjust schedules to accommodate the inherent nature of CNG use. Fueling the CNG trucks will utilize the time-fill method, which will require operators to connect to the fill station at the end of the shift to ensure trucks are full at the start of the next work shift. AES will monitor emissions and record metrics to prove the efficiency and reliability of the system.

Accomplishments

ACES has placed orders for two Kenworth T880 CNG trucks, one equipped with a Westmark 90bbl vac unit and one equipped with a Westmark potable water unit. ACES placed truck orders in February 2023 with anticipated delivery in 4Q 2023. Due to increased demand for CNG engines, the truck delivery has been delayed until late 1Q 2024. Currently October 2023 build slots are scheduled. Due to the delays in truck delivery, the DOE granted an extension for Budget Period 1.

ACES ordered the gas compression and CNG fueling station in March 2023. The units were completed, and factory commissioned in early September 2023. Currently the units are being shipped from Bend, Oregon to Anchorage, Alaska, with an anticipated delivery in mid-October 2023. See Figure I.38.1 through Figure I.38.4.

Figure I.38.1 Factory commissioned CNG compressor awaiting shipping from Bend, Oregon

Figure I.38.2 Factory commissioned fueling station awaiting shipping in Bend, Oregon

Figure I.38.3 Shrink wrapped compressor awaiting barge shipping to Anchorage, Alaska

Figure I.38.4 Shrink wrapped fueling station in Seattle, Washington awaiting barge shipping to Anchorage, Alaska

Results

There have been no results to report to date.

I.39 Development of an Electric Vehicle Associate's Degree Curriculum Standards and Educational Materials for Automotive Educators and Technicians Nationwide (West Virginia University Research Corp.)

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Start Date: March 1, 2023 End Date: October 31, 2024
Project Funding: $1,000,000 DOE share: $1,000,000 Non-DOE share: $0

Project Introduction

The National Alternative Fuels Training Consortium (NAFTC) led by West Virginia University (WVU) is researching and developing a pathway for a ***credentialed***, ***diverse*** electric vehicle (EV) technical workforce to support the current U.S. goal that by 2030, 50% of all new vehicles sold will be electric or zero emission vehicles. While multiple efforts to develop an EV curriculum have arisen in recent years, there remains to be a consensus on the components of an accreditable associate degree (AAS degree) curriculum for EV automotive maintenance and repair. The project is to research, develop, and deploy a model framework for a standards-driven Community and Technical College (CTC)-based associate degree with a specialization in electric drivetrain repair and maintenance for automotive, transit, and class 1-8 electric vehicles. WVU is identifying recommended general and specialty courses for the degree along with minimum standard EV coursework. Because automotive programs in some regions of the U.S. may be delivered primarily by Career and Technical Education (CTE) Institutions of K-12 public education systems, the model will include a pathway for high school students to convert high school coursework to college credits toward an associate degree. Further, the model will include a career exploration/workforce development component targeted to youth, women, minorities, economically disadvantaged, and other underrepresented populations to address workforce diversity, especially related to gender equity in the industry.

Eight community and technical colleges across the U.S. are participating in the project.

Objectives

The objective is to develop a recommended framework for an AAS degree that can be adopted by an accrediting agency for promulgation of national standards for EV technicians. The goal is to ensure the creation of a fully competent workforce to serve employers' needs.

Approach

Select NAFTC members (CTCs and CTEs) from across the U.S. are collectively reviewing how CTCs and CTEs are approaching EV education, identifying best practices, reviewing educational materials, identifying gaps, and addressing those gaps to arrive at a two-year degree program to establish a national standard in EV education and training. The team will conduct a train-the-trainer roll out of the model for up to 36 educational institutions with automotive programs. Trainings will be provided online through the development of a web based NAFTC Learning Center and in person to reinforce for instructors the necessary hands-on components of EV education. An Employers Council consisting of the respective project team members' industry advisory committees ensures a strong match between job knowledge required, the associated credentials, and employers' needs. WVU will develop a plan to expand the credentialing effort beyond the funding period.

Results

WVU recruited select CTCs to participate in the project. They represent urban and rural settings, those that are early promoters of EV education due to the demand in their service areas, and those that are just beginning to respond to expected demand. Those that signed on include:

- BridgeValley Community and Technical College, Charleston, WV
- New River Community and Technical College, Ghent, WV
- Tarrant County College, Arlington and Fort Worth, TX
- University of Northwestern Ohio (UNOH), Lima, OH

Additional schools engaged in discussions about becoming participants with the expectation that they would make a likely positive decision to join by late 2023 or early 2024. They include:

- Ferris State University, Big Rapids, MI
- Weber State University, Ogden, UT
- Wake Tech, Raleigh, NC
- Rio Hondo College, Wittier, CA

BridgeValley and New River aspire to adopt EV education for their largely rural demographic. Both are aware that while West Virginia may be the state with the lowest EV adoption rate, EVs now are part of the long-term transportation mix for which well-prepared students need to be educated. Tarrant County currently offers hybrid and battery electric vehicle (BEV) systems diagnostics as a capstone course in its automotive service technology AAS. UNOH offers a dual approach focused on the design, controls, and operating characteristics of hybrid and BEVs as well as gasoline-powered vehicles. Ferris State faculty have nearly 20 years' experience offering students hybrid and EV training and is currently a part of a National Science Foundation effort to expand EV education. Wake Tech unveiled its new Hendrick Center for Automotive Excellence, a 100,000 square foot facility dedicated to "a new skilled workforce capable of servicing the latest vehicle technology, including hybrid and all-electric vehicles."[1] Weber State is known nationwide for its hybrid and EV online course and in-person bootcamp offered in their non-credit program, the same coursework offered to Weber State automotive students but tailored to the working professional or hobbyist. Rio Hondo was among the first seven Tesla START training schools and was central to the development of Class 8 EV curriculum under the Volvo LIGHTS program.

WVU curriculum and instruction experts culled academic requirements for these and other AAS degree programs to arrive at an initial, sample framework for an EV AAS. Table I.39.1 lists their findings.

Table I.39.1 Sample Pathway 1: AAS Degree, EV Repair (Inclusive of General Education & Electives)

Semester 1	Semester 2
100 Level Math (Algebra*) AC Electronics DC Electronics Computer Science (Computing Systems*) Intro to EV and Hybrid Technology 100 Level English	200 Level Math (Mathematics in Technology*) Braking Systems Critical Reading & Composition Humanities (Environmental Ethics*, History of Auto, Sociology) Physical Science (Physics*, Chemistry)
Semester 3	**Semester 4**
Electrical and Chassis Control High Voltage Electric Climate & Thermal Regulation Steering & Suspension Systems Speech & Communications	Battery Technology Digital Electronics Internship/Site Focus Business coursework (Human Resources*, Accounting, Entrepreneurship)

*** Asterisk denotes recommended class for general education course based on existing programs.**

The multimedia development team designed a system for the digital delivery of curriculum, the NAFTC Learning Center. Components include a Library for the storage and retrieval of NAFTC curriculum and a Community Room where NAFTC instructors can share their own course content, seek assistance from others, and otherwise engage in networking around alternative fuel vehicles. A special section has been established in the Community for hybrid and EV discussions. The Learning Center is not a learning management system (LMS). Institutions often require the use of a specific LMS or other record-keeping online system which the Learning Center is not intended to duplicate. Rather, digital delivery of curriculum is the more affordable and convenient way for instructors and students to access what can be very expensive educational materials. Instructors have reported to NAFTC leadership that they choose their educational materials with students' budgets in mind, aware that many students, especially non-traditional students, have other financial obligations that extend beyond financing their educations. Accessibility and affordability are foremost considerations for this project.

The system supports bulk file uploads to cloud storage and allows referencing of shared materials across multiple curricula. The content viewer accommodates diverse file formats, incorporating security measures against unauthorized downloads and enabling watermarked PDF downloads for authorized users. Internal/external hyper-references can be integrated, and instructors can provide feedback. The feature-rich viewer also facilitates page bookmarking. Instructors can create classes, compile resources, and manage visibility. A favorites feature allows users to organize materials, while upcoming developments include expanded curriculum fields, thumbnail previews, error handling, and refining role assignments.

Conclusions

A standard framework for coursework leading to an AAS degree specializing in EV maintenance lays the foundation for an accreditation program that is currently missing from today's educational landscape. The project is seeking consensus on that framework from a number of well-positioned educational institutions that could be expanded nationwide to ensure a workforce qualified to ensure the operation and safety of EVs.

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II National Laboratory Projects

II.1 AFLEET Tool (Argonne National Laboratory)

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Start Date: October 1, 2022 End Date: September 30, 2023
Project Funding (FY23): $300,000 DOE share: $300,000 Non-DOE share: $0

Project Introduction

This project updates and expands the existing Alternative Fuel Life-Cycle Environmental and Economic Transportation (AFLEET) Tool first released in 2013. Researchers at Argonne National Laboratory (Argonne) developed the AFLEET Tool for the U.S. Department of Energy (DOE) Vehicle Technologies Office's (VTO) Technology Integration Program to estimate petroleum use, emissions, and cost of ownership of light-duty vehicles (LDVs), heavy-duty vehicles (HDVs), and off-road equipment, using simple spreadsheet inputs. AFLEET examines both the environmental and economic costs and benefits of conventional, alternative fuel, and advanced technology vehicles for 18 different fuel and vehicle pathways, 10 major vehicle types and 27 different vocations. The tool has both a Simple Payback calculator, to examine the payback of a new conventional vehicle versus an alternative fuel vehicle (AFV), and a Total Cost of Ownership (TCO) calculator that examines the costs during the entire life of the vehicle. AFLEET also includes a calculator to estimate the environmental impacts of public electric vehicle (EV) charging.

In addition, Argonne developed a user-friendly online version of AFLEET to supplement the spreadsheet version. Since AFLEET's inception the number of users has grown to 12,100 individuals for the spreadsheet and 14,900 for the online version. The primary audiences for this tool are Clean Cities directors, industry, fleet managers, academia, and policymakers at all levels of government. The tool can be accessed directly from Argonne's web site or from the Alternative Fuels Data Center website [1]. The tool has been used to examine real-world fleet data for several VTO case studies, authored by Argonne.

Objectives

In fiscal year (FY) 2023, the AFLEET Tool had several factors that needed updating. AFLEET required an annual update to match new modeling results from GREET [2]; new fuel price data from the Alternative Fuel Price Report (AFPR) [3], and the Energy Information Agency (EIA) [4]. In addition, to update vehicle operation air pollutant emissions of LDVs and HDVs, as well as off-road equipment, Argonne utilized state-level emission factors generated from the U.S. Environmental Protection Agency's (EPA's) MOVES model [5].

The Infrastructure Investment and Jobs Act called for AFLEET (or similar tool) to be used to estimate emission benefits from alternative fuel refueling infrastructure for the Federal Highway Administration's Charging and Fueling Infrastructure Discretionary Grant Program (CFI Program). In FY 2023, Argonne released a standalone tool for the CFI Program, as the Federal Highway Administration opened applications for its first round of funding. From this effort, Argonne wanted to adopt these calculations into the full

AFLEET, including fuels outside the scope of the CFI Program. In addition, Argonne finalized calculations and data to examine the costs of charging EVs.

AFLEET Online had only included the Simple Payback Calculator for on-road vehicles from the Excel version since being released in FY 2019. As the Excel version of AFLEET Tool has expanded, stakeholders expressed the desire for more of those calculators to be added to the Online tool. Therefore, Argonne developed two new calculators for AFLEET Online: Total Cost of Ownership for on-road vehicles and Simple Payback Calculator for off-road vehicles. As part of this effort Argonne redesigned the front-end with a new and more responsive interface for the new calculators, which also replaced the interface for the Simple Payback Calculator for on-road vehicles.

Approach

Argonne used the GREET model as the basis to update existing data in AFLEET, and to update default fuel economy and electricity consumption data for both LDVs and HDVs. Due to strong interest from stakeholders, Argonne added placeholder renewable propane pathways to AFLEET based on GREET renewable diesel data (until they are officially included in GREET). In addition, Argonne added a user cooking oil biodiesel pathway. GREET 2022 added the capability to examine the environmental impacts of vehicle production for three (3) HDV types. AFLEET has seven (7) HDV types based on EPA MOVES categories, and therefore needed to expand upon GREET's modeling capabilities. Argonne collected data on component level weights from Argonne's Autonomie model simulations and modified GREET to estimate the vehicle production emission impacts for four powertrain types: diesel, diesel hybrid, battery electric, and fuel cell [6]. Argonne also estimated the HDV production impacts for eleven additional powertrain technologies in AFLEET that were not available in Autonomie simulations, including compressed natural gas and propane.

AFLEET uses fuel price data from the Vehicle Technologies Office's AFPR for the Simple Payback and TCO calculators, and fuel price escalation factors from the EIA's Annual Energy Outlook for the TCO calculator. These values change each year, so Argonne updated AFLEET to account for the latest data.

The AFLEET CFI Tool estimates the emission impacts of refueling infrastructure projects for Level 2 and DC Fast chargers, as well as hydrogen, propane, compressed natural gas, and liquefied natural gas fueling stations. The tool calculates the emission reductions from a baseline fuel (i.e., gasoline or diesel) based on fueling infrastructure utilization (e.g., kWh or hydrogen kg dispensed per year), vehicle mix (e.g., % light-duty vehicle versus % HDVs), and feedstock type (e.g., fossil natural gas versus renewable natural gas). For AFLEET 2023, the CFI Tool's methodology was included in a new calculator that added five additional fueling station types, including biodiesel, renewable diesel, and ethanol.

In addition to emission analysis of EV charging infrastructure, Argonne developed the EV Utility Rate Calculator which estimates the cost of charging by examining utility-specific electricity rates for EV residential, public, and fleet charging, while also considering rate type, charger rating, charging period/strategy, and vehicle requirements. It addresses energy, demand, and fixed charges for summer and winter, and off-peak, mid-peak, and on-peak variability. The underlying rate data used in the calculator is from the Utility Rate Database and includes 1,770 commercial rates and 747 residential rates [7]. Argonne built the calculator to handle a wide range of rate designs, including time-of-use structures for both energy and demand charges. Argonne also developed the EV Charger TCO Calculator to assess the levelized and net present value costs of charging a fleet's EVs, by analyzing utilization, capital costs (charger and make-ready), annual operating costs (communications, warranty, maintenance), and electricity costs, to present a full, organization-specific cost of charging an EV fleet.

AFLEET Online added two new calculators: Payback Off-Road and TCO, as well as a redesigned homepage and user interface for Payback On-Road. See Figure II.1.1. The front-end was designed in Svelte JavaScript framework that allowed for building reusable components that make updating and expanding AFLEET Online easier.

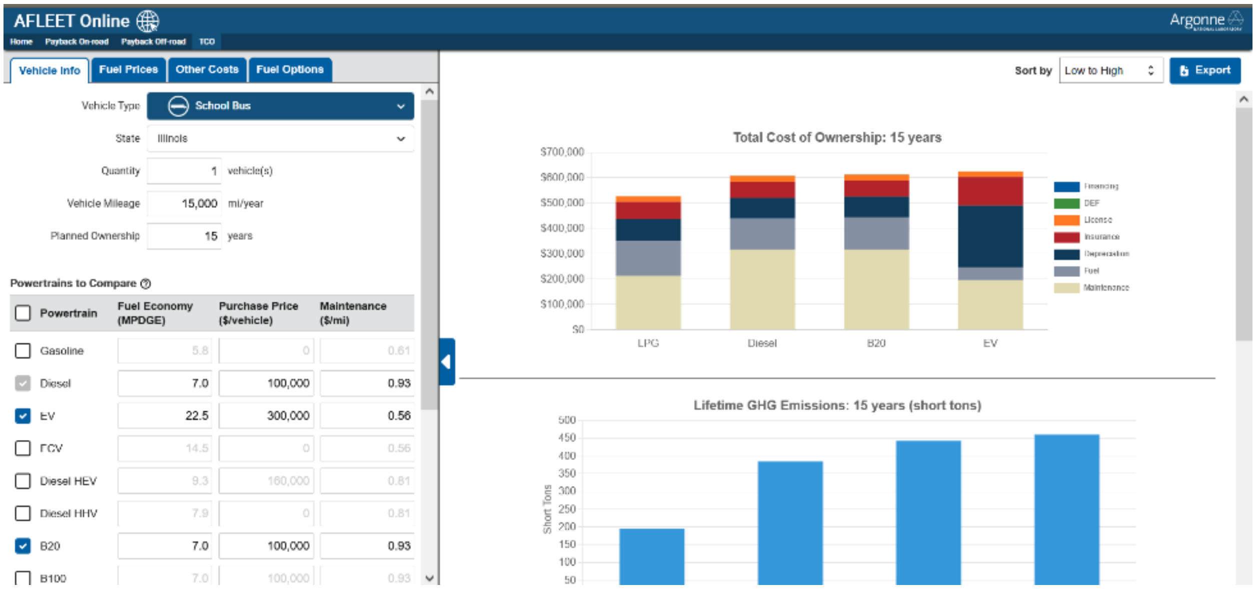

Figure II.1.1 AFLEET Online TCO Calculator Interface

Results

During FY 2023, users downloaded the AFLEET Tool about 1,100 times, and the accompanying AFLEET user manual about 2,800 times. To date, 12,100 individual users have downloaded the tool. The user-friendly AFLEET online tool released in FY 2019 had about 14,900 new users.

Conclusions

In FY 2023, this project addressed the stakeholder requests to continue updating both the AFLEET spreadsheet and online versions with the latest emissions and cost data. This included incorporating data from the latest GREET research, EPA MOVES simulations, AFPR station prices, and vehicle and charging costs. In addition, Argonne developed two new online calculators to help stakeholders estimate the emission and cost impacts of alternative fuel on-road vehicles and off-road equipment.

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II.2 Battery Workforce Challenge Program (Argonne National Laboratory)

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Start Date: October 1, 2022 End Date: September 30, 2023
Project Funding (FY23): $5,000,000 DOE share: $3,500,000 Non-DOE share: $1,5000,000

Project Introduction

The U.S. Department of Energy (DOE) has set a bold target that puts our nation on a path to achieve net-zero emissions, economy-wide, by 2050 to address the climate crisis for the benefit of all Americans. Key to this goal are the design and development of advanced batteries to electrify the transportation and energy sectors. The Battery Workforce Challenge Program seeks to build a highly skilled domestic workforce with the hands-on experience and knowledge needed for in-demand positions throughout the electric vehicle (EV) and battery industries. Li-bridge, a public-private alliance committed to accelerating the development of a robust and secure domestic supply chain for lithium-based batteries, estimates that the battery industry workforce will have a demand of 230,000 people by 2030, including over 30,000 engineers and over 160,000 skilled workers and technicians. [1] DOE has initiated this new comprehensive workforce development program to build a diverse, domestic workforce to fill in-demand positions throughout the battery and EV supply chain. Managed by Argonne National Laboratory (Argonne), the Battery Workforce Challenge (BWC) Program aims to educate, train, and connect skilled workers across the talent spectrum to in-demand jobs that the historic growth of the North American EV and battery industry are creating, through four key components.

Argonne was tasked with this battery workforce development initiative based on a strong foundation in engineering workforce development through 35 years of managing Advanced Vehicle Technology Competitions (AVTCs). AVTCs are premier collegiate engineering competitions sponsored by the DOE and leading industry sponsors which provide a pipeline from universities to competitive engineering, communications, and leadership roles. The BWC expands this university engineering competition into vocational competitive elements such as advanced manufacturing and technicians for testing.

Beyond the BWC Collegiate Competition, this project has developed initiatives to address transitional workers, regional workforce training, and Science, Technology, Engineering and Mathematics (STEM) education enhancements into battery fields. This project also incorporates a method for deploying training and education through a learning ecosystem on a nationwide scale to address the imminent demand for skilled workers in the battery and EV industries.

Objectives

The objectives for Battery Workforce Challenge Program are as follows:

- Develop and release a Request for Proposals in winter 2023 to solicit universities to join a new AVTC, namely the Battery Workforce Challenge Competition, co-headline sponsored by DOE and Stellantis.

- Market to Accreditation Board for Engineering and Technology (ABET) accredited universities including diverse Historically Black Colleges and Universities (HBCUs), Minority Serving Institutions (MSIs) and Asian American and Native American Pacific Islander-Serving Institutions (AANAPISIs) and encourage them to apply for participation into the Battery Workforce Challenge competition. Engage and respond to questions to clarify requirements and ensure barriers to participation are fair.
- Integrate a vocational element into the AVTC to expand the impact of the competition beyond ABET accredited universities.
- Review university proposals and select participant universities with agreement from co-headline sponsors before Fall 2023.
- Launch the Competition in Fall 2023.
- Solicit additional sponsors to support the competition and other BWC initiatives.
- Successfully plan, manage, and execute the AVTC for DOE and ensure the competition is executed with technical integrity and fairness for all university and vocational competitors.
- Incorporate current industry codes and standards into the testing and evaluation of the competition vehicles and batteries.
- Develop safety practices and procedures for university and vocational competitors to ensure a safe competition.
- Develop real-world, multi-year training and education programs on advanced vehicle and battery technologies for university and vocational competitors with subject matter experts from government and industry to develop a highly skilled workforce.
- Expand battery workforce development beyond the AVTC to address workforce needs related to non-engineering skillsets through diverse, equitable and inclusive methods.
- Develop initiatives to effectively address specific areas within the educational pipeline from training to workforce deployment.

Approach

Through four initiatives developed and initiated throughout FY23, Argonne is partnering with industries and academic institutions to help build high-quality North American made batteries and EVs. The four initiatives are:

Battery Workforce Challenge Collegiate Competition

DOE, in partnership with Stellantis, has introduced a new three-year AVTC managed by Argonne. The competition challenges 12 universities, in partnership with strategic vocational partners, to design, build, test and integrate an EV battery pack into a Stellantis production vehicle.

Battery Workforce Challenge STEM Outreach

The STEM outreach initiative focuses on introducing youth to careers in STEM, including battery/EV design and manufacturing. Experiential design and build challenges will be deployed to generate excitement and interest in STEM and recruit youth into Career Technical Education (CTE) courses developed by the program, to train students for direct to career jobs in manufacturing.

Battery Workforce Challenge Regional Workforce Training

Regional workforce training development will focus on geographic locations where EV and battery manufacturing are growing. Bringing together local Departments of Labor, training institutions and community leaders, the Regional Workforce Training Initiative will support vocational training and education, and reskilling/upskilling of workers transitioning from other industries to succeed in the shifting job market.

Career-Connected Learning Management System

In support of the first three initiatives, the Career-Connected Learning Management System (LMS) is being deployed to provide an online, accessible platform accessible by all learners and skill levels. The LMS will support all Argonne workforce development programs and provide scalable deployment as well as opportunities for micro-credentialing.

Results

Battery Workforce Challenge Competition

The Battery Workforce Challenge Competition was conceptualized as a 3-year competition with shifting focuses across the years to design, build, test and integrate a full EV battery pack into a production Stellantis vehicle. The first year, starting in Fall 2023 to coincide with the academic calendars, will focus on the design of the battery pack, including architecture selection, cell characterization and algorithm development. The second year will focus on building the battery pack and bench testing. The third year will focus on integrating the student designed and built battery pack into the vehicle and testing the vehicle performance until the competition concludes in Spring 2026.

Argonne, in partnership with DOE and Stellantis, announced and released the Battery Workforce Challenge Request for Proposals (RFP) in March 2023 through a press release and targeted marketing campaign to 151 ABET accredited universities. The marketing campaign included a focus on various accredited minority serving institutions and tracked the engagement of the community with the RFP and website. Table II.2.1 summarizes the campaign outreach.

Table II.2.1 Summary of Battery Workforce Challenge RFP marketing campaign

Category	Targeted	Downloaded RFP	Submitted proposal	Accepted into competition
Total universities	151	109	18	12
MSI universities	42	18	5	4
HBCU universities	17	4	1	1

The target deadline for proposal submission was set to May 18, 2023, with a two-week extension deadline offered to help universities that needed more time to complete the proposal process in consideration of the shortened proposal writing duration caused by announcement delays. Argonne held a live webinar in April 2023 to address questions submitted by universities, solicit additional questions, and provide technical and logistical clarifications.

Twenty-two universities expressed an intent to submit a proposal. Eighteen universities submitted proposals for consideration into the Battery Workforce Challenge Competition for 11 announced positions in the RFP. Argonne completed the proposal scoring process in June 2023 and the selection process in July. Twelve universities were selected for the competition. They are strategically located in geographical regions tied to EV and battery manufacturing based on projections through 2030 published by Gohlke, et al. [2] Table II.2.2 and Figure II.2.1 show selected universities participating in the inaugural Battery Workforce Challenge Competition.

Table II.2.2 Teams Participating in the Battery Workforce Challenge Year 1

Team	Abbreviation	Team	Abbreviation
California State University, Los Angeles	Cal State LA	Rose-Hulman Institute of Technology	RHIT
Clemson University	CU	University of Alabama	UA
Colorado School of Mines	Mines	University of California, Merced	UC Merced
Jackson State University	JSU	University of Michigan, Dearborn	UM-Dearborn
McMaster University	MAC	University of Nevada, Las Vegas	UNLV
The Ohio State University	Ohio State	University of Waterloo	Waterloo

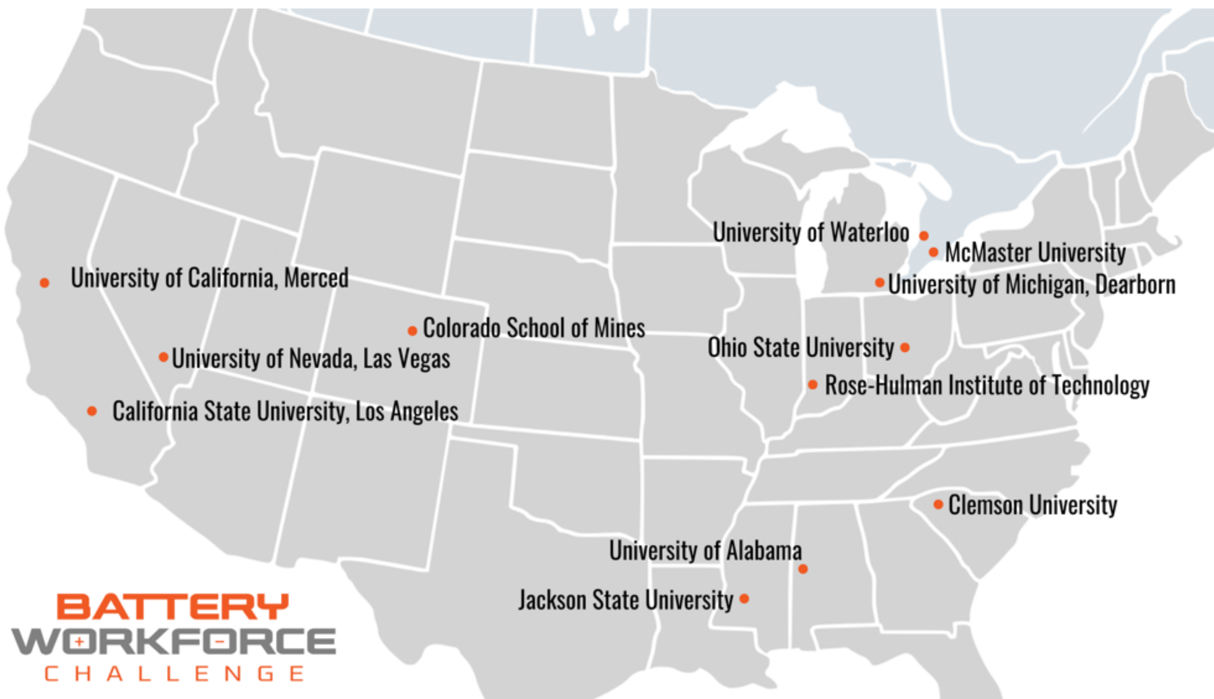

Figure II.2.1 Battery Workforce Challenge Competition Teams

The virtual launch of the competition occurred on September 14, 15, and 21, 2023, in concurrence with the release of the key rules and requirement documentation of the competition released on September 12. The first in person event is a Fall Workshop planned for October 12–14, 2023, in Alexandria, VA to provide battery and competition specific training and networking for faculty, students, sponsors, and organizers.

Year 1 of the competition includes further virtual training through live online webinars, and an in-person winter workshop in March 2024 with additional training and initial design reviews by the teams judged by competition sponsors. A year end in-person Competition Event is planned for May 2024, where students will present their final year 1 designs and demonstrate their progress through an EXPO event.

Though the proposal required ABET accreditation to apply, it also included a required partnership with a vocational institution to extend the impact of the Battery Workforce Challenge competition. Since the formation of the partnership during the proposal writing period was unrealistic, the proposal only required suggested partnerships. The actual partnership establishment was planned for the Fall 2023 semester and is currently underway with the goal of establishing the formal partnership in calendar year 2023.

Recruitment for additional sponsors launched in August 2023, targeting existing AVTC sponsors as well as battery and EV industry potential sponsors with relevant tools, components, and expertise for teams to succeed in the competition. In FY23, Argonne, Stellantis, and DOE contacted over 70 potential sponsors and provided the sponsorship package to engage on potential participation. Four sponsors were successfully recruited and signed on ahead of the fall workshop and four additional sponsors are in active negotiation to participate and support the teams.

Battery Workforce Challenge STEM Outreach/Regional Workforce Training

The Battery Workforce Challenge Program is DOE's comprehensive EV and battery workforce development program. It fosters a diverse talent pipeline by building an educational ecosystem that delivers training and education for high school graduates, vocational and transitional workers, and technicians who can charge North America's battery industry forward.

In FY23, the Argonne team created plans to develop regional workforce training hubs for battery industry related skills and STEM CTE programs to support the pipeline across the educational spectrum. This includes K-12, skilled trades, community colleges, other vocational institutions, and universities as well as reskilling/upskilling workers in other sectors to succeed in the emerging United States battery and EV industries.

Sponsorship outside of the competition is in active negotiation for forming Regional Workforce Training hubs in FY24.

Career-Connected Learning Management System

Essential across all Battery Workforce Challenge Program initiatives is the national Career-Connected Learning Management System (LMS). This online tool will provide flexible, accessible, and equitable training and job opportunities for learners across the education pipeline including high school graduates, transitional workers, and University graduates. Argonne considered several potential platforms for the LMS during FY23. The Argonne team evaluated three leading options and recommended Moodle to DOE, which approved the selection in August 2023. Argonne procured the platform in FY23, and content development and deployment are planned for FY24.

Conclusions

Argonne successfully launched the Battery Workforce Challenge Competition in FY23 with 12 selected universities across North America in geographical locations strategic to the EV and Battery industries. The Battery Workforce Challenge initiatives were defined in detail to target STEM outreach, Regional Workforce Training and the 3-year competition using a Career-Connected Learning Management System.
The Battery Workforce Challenge Program will build upon the FY23 work to develop content and deploy the initiatives throughout FY24, while continuing to manage the 3-year competition with universities and their partnering vocational schools.

Key Publications

Battery Workforce Challenge – Request for Proposal

References

[1] Li-Bridge 2022 Compendium

[2] David Gohlke, Yan Zhou, Xinyi Wu, and Calista Courtney, Argonne National Laboratory, **Assessment of Light-Duty Plug-in Eectric Vehicles in the United States, 2010–2021**, ANL-22/71, 2022.

II.3 Advanced Vehicle Technology Competitions: EcoCAR EV Challenge (Argonne National Laboratory)

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Start date: Oct. 1, 2022 End date: Sept. 30, 2023
Project Funding (FY23): $6,200,000 DOE share: $4,000,000 Non-DOE share: $2,200,000

Project Introduction

The U.S. Department of Energy, MathWorks and General Motors have joined forces with more than 20 government and industry sponsors to establish the EcoCAR EV Challenge, a four-year DOE Advanced Vehicle Technology Competition. This workforce development program will seed the industry with more than 2,000 engineering, communications and business graduates who have hands-on experience designing, building, and promoting advanced technology vehicles and connected and automated vehicle technologies. Managed by Argonne National Laboratory, EcoCAR challenges 15 North American universities to:

- Meet the decarbonization needs of the automotive industry by applying automation and connectivity technologies to state-of-the-art battery-electric vehicle platforms.
    - Utilize a combination of on-board sensors and bidirectional vehicle-to-everything (V2X) connectivity to implement energy efficient and customer-pleasing automated control features.
    - Implement and refine advanced powertrain, charging, and thermal systems to use grid electricity intelligently.
- Identify and address specific equity and electrification challenges in the future of mobility through the application of innovative hardware and software solutions.
- Establish and maintain effective relationships with team-selected target market to guide design decisions and implementation throughout the vehicle development process.
- Balance energy efficiency needs with consumer acceptability, safety, and equity in mobility considerations. EcoCAR teams are following GM's Vehicle Development Process (VDP), which serves as a roadmap for designing, building, and refining their advanced technology vehicles.

This unique real-world engineering competition provides student engineers with hands-on research and development experience with leading-edge automotive components and technologies. The competition just concluded its first year, culminating with each competing team being notified of its approved vehicle architecture. They will be responsible for executing on this architecture over the remaining three years.

Objectives

The objectives for the EcoCAR program are as follows:

- Develop a highly skilled workforce, knowledgeable in advanced technology vehicles.
- Incorporate current industry codes and standards into the testing and evaluation of the competition vehicles.
- Develop safety practices and procedures for university competitors to ensure a safe competition.
- Develop real-world, multi-year training and education programs focused on advanced vehicle technologies for university competitors, with subject matter experts from government and industry.
- Promote and build awareness about the program and prepare the marketplace to adopt advanced technology vehicles.
- Facilitate youth outreach to increase Science, Technology, Engineering, and Math (STEM) awareness, including among underrepresented minorities.
- Recruit and retain students that represent the diversity of automotive customers and promote an environment of inclusion and diversity within the program and among the participating teams.

Table II.3.1 lists the university teams participating in the EcoCAR EV Challenge along with the abbreviations used in this report.

Table II.3.1 Teams Participating in the EcoCAR EV Challenge

Team	Abbreviation	Team	Abbreviation
Embry-Riddle Aeronautical University and Bethune Cookman University*	ERAU-BCU	The Ohio State University and Wilberforce University*	OSU-WU
Georgia Institute of Technology	GT	University of California – Davis	UCD
Illinois Institute of Technology	IIT	University of California – Riverside	UCR
McMaster University	MAC	University of Waterloo	UWAFT
Mississippi State University	MSU	Virginia Tech	VT
University of Alabama	UA	West Virginia University	WVU
University of Texas	UT		

*Denotes a collaboration between two universities

Approach

Fiscal Year (FY) 2023 roughly aligned with the first year of the EcoCAR EV Challenge. This 4-year competition series launched in August of 2022 and runs through May of 2026. Over the four years of the EcoCAR EV Challenge, each team will design, build, test, and refine an advanced technology vehicle. Teams receive milestones for each year of the competition to guide them through the full development process, covering multiple academic years. This Vehicle Development Process (VDP) mimics General Motors' own VDP and provides developmental goals for the teams and their vehicles.

Each year of the competition, teams are provided with a detailed set of technical goals for their vehicle development process. These goals are useful to provide uniform expectations across all teams for vehicle development milestones throughout the four-year competition series. A summary of these goals is provided below in Table II.3.2.

Table II.3.2 Technical Goals for Year 1 of the EcoCAR EV Challenge

Subteam	Goals

Propulsion Controls and Modelling	• Evaluate potential energy consumption and vehicle performance using MATLAB/Simulink virtual vehicle model.
	• Establish team-defined Vehicle Technical Specifications to serve as technical goals for the vehicle for Year 2 of the competition.
	• Use CAD from both GM and motor sponsors to propose potential packaging solutions for 3 EV architectures.
	• Perform and submit an extensive architecture selection study analyzing energy consumption, vehicle acceleration, and hardware packaging to finalize the EV architecture for the remaining years of the competition.
	    o Involves a rigorous effort to analyze the integration challenge from an engineering perspective in terms of both hardware and software implementation.
	    o Primary output of Year 1: Teams have their selected propulsion architectures based on organizer approval of their proposals

Connected and Automated Vehicle System	• Set up the team's foundational tools to enable standardized development platform including Git Repositories, simulation tools, deployment middleware, and programming languages.
	• Design the software and hardware architectures for the CAV features in EcoCAR, which include, Eco-Cooperative Adaptive Cruise Control, Automatic Intersection Navigation with Eco-Approach and Departure, and Automatic Parking.
	    o Conduct market research and sensor studies to understand the feasibility of each sensor suite.
	    o Map out all software components for full CAV system including perception, planning, controls, decision making, vehicle state prediction, diagnostics, state machines, and data logging.
	• Develop a functional sensor fusion system in a team-decided simulation environment.

To assist teams in meeting these year-end goals, the competition held two in-person workshop events prior to the year-end competition event. The first was a Fall Workshop in October 2022 at the University of California, Davis Campus in Davis, California. This Fall Workshop event accomplished two main objectives:

- Teams acquired critical information pertaining to the new 4-year competition series, including information on competition structure, technical overview and challenges, and building a strong and successful team.

- Each sub team (Diversity, Equity, and Inclusion, Project Management, Communications, Connected and Automated Vehicles, Propulsion Controls and Modeling, and System Design and Integration) received key training from both industry sponsors and Argonne trainers on topics relating to the team's Year 1 Fall Deliverables.

The second in-person event brought all teams to Austin, Texas in February of 2023. Argonne personnel curated this workshop to be geared more towards individual team one-on-one sessions, each with industry subject matter experts or Argonne organizers. These hour-long sessions covered various topics relating to Year 1 Spring Deliverables. In addition, there were a few combined trainings, split by sub team, to cover content that all teams needed to consume equally. Roundtables were also held for each sub team to gather feedback from students and integrate it into future content.
The competition event for Year 1 of the EcoCAR EV Challenge was held in May of 2023 in Orlando, Florida. At this event, over 60 industry judges from more than 15 industry sponsors took part in scoring hour-long

professional presentations given by teams. These presentations were split up by sub team, and each had their own requirements set forth by Argonne and GM organizers. There was also a symposium related to Equity in Mobility where teams presented a large poster covering research they completed relating to Equity in Mobility near their school locations. Table II.3.3 summarizes the scored events that evaluated EcoCAR team performance during Year 1 Final Competition.

Table II.3.3 Presentations during EcoCAR EV Challenge Year 1 Final Competition

Topics for Required Judged Presentation Events	Elective Judged Events
Connected and Automated Vehicle	MathWorks Model-based Design Presentation
Diversity, Equity, and Inclusion	
Equity in Mobility	
Project Status	GM Women in STEM Presentation
Communications	
Propulsion Controls & Modeling	
System Design & Integration	

Results

Student Participation and Employment Outcomes

The program was successful in achieving its core objective: training the next generation of automotive engineers, communicators, and business leaders. Table II.3.4 summarizes total student participation since the beginning of the EcoCAR EV Challenge.

Table II.3.4 EcoCAR EV Challenge Student Participation by Major (to date)

Major	Total	% of Total	STEM?
Mechanical Engineering	207	33%	Y
Electrical/Computer Engineering	141	23%	Y
Computer Science & Software Engineering	118	19%	Y
Mechatronics Engineering	25	4%	Y
Other STEM Majors	56	9%	Y
Non-STEM Majors	77	12%	N
Total	**624**	**100%**	–

EcoCAR students secured internships, co-ops, and full-time jobs at a wide variety of companies. Nearly 200 companies hired a total of 273 EcoCAR students during FY2023 (53 full-time employees and 220 internships). EcoCAR students found employment in a vast array of industries and geographic locations, but automotive industry companies are the number employer of EcoCAR students and hired students at a rate two times higher than any other industry sector. Additionally, EcoCAR students who accepted full-time jobs during this period commanded a salary premium compared to their non-EcoCAR peers, earning $5,500-$14,400 more in their first full-time professional job after graduating (depending on major).

EcoCAR Team Local Outreach Activities

EcoCAR teams implement community and STEM outreach programs to promote Advanced Vehicle Technology Competitions (AVTCs), clean energy, and STEM opportunities. During Year 1, EcoCAR EV

Challenge teams conducted a total of 47 youth outreach events for underserved and underrepresented youth reaching a total of 7,637 youth in grades k-12. Teams conducted 19 community events with the general public, reaching 19,643 community members.

Diversity, Equity, and Inclusion (DEI) and Equity in Mobility Initiatives

In Year 1 of the EcoCAR EV Challenge, substantial progress was made toward laying a foundation of Diversity, Equity, and Inclusion (DEI) throughout EcoCAR and teams. EcoCAR teams received intensive DEI training at the Fall Workshop (October 2022) and Winter Workshop (February 2023) for DEI managers and general DEI training for all EcoCAR team members. Teams developed relationships with university DEI specialists and minority serving engineering student organizations such as:

- Society of Women Engineers (SWE)
- Society of Hispanic Professional Engineers (SHPE)
- National Society of Black Engineers (NSBE)
- American Indian Science and Engineering Society (AISES).

During Year 1, Argonne also launched the Equity in Mobility Challenge for EcoCAR teams. This initiative challenged EcoCAR students to research underserved stakeholder groups in their local communities and identify mobility barriers hindering those community groups. At the end of the year, teams presented their research efforts at the Equity in Mobility Symposium during Year 1 competition. EcoCAR teams will use this research as a foundation for future community engagement efforts in future years of the program.

Team Selection and Minority Serving Institution (MSI) Funding

From the inception of the EcoCAR EV Challenge, Argonne and DOE have aimed to provide equitable opportunities for participation and success of new universities in AVTCs. This aim was maintained through every phase of development of the EcoCAR EV Challenge - starting with the University Recruitment Campaign, through the request for proposal (RFP) process, and the Team Selection Process. As a result of these efforts, five of the 15 universities competing in the EcoCAR EV Challenge are Minority Serving Institutions (MSI):

- Bethune Cookman University (in partnership with Embry Riddle Aeronautical University)
- University of California – Davis (emerging MSI)
- University of California – Riverside
- University of Texas, Austin
- Wilberforce University (in partnership with The Ohio State University).

DOE is supporting Bethune Cookman University (BCU), UC-Davis, UC-Riverside, and Wilberforce University teams with $250,000 in seed money (each) over four years. This funding will allow these universities to build out the infrastructure supporting EcoCAR activities and enriching the diverse student populations they serve. During FY23, contracts with each university were completed to deliver these grants and a total of $400,000 was awarded to these four university teams.

Propulsion System Architecture Selection

Propulsion system architecture selection was the primary output for the propulsion, controls, & modeling (PCM) and systems design & integration (SDI) sub teams in Year 1 of the EcoCAR EV Challenge. This exercise was the culmination of a year's worth of computer aided engineering studies, using MATLAB/Simulink to analyze architecture performance, and using NX tools to study packaging feasibility of different architectures.

The primary focus for teams in architecture selection was the motor/drive unit they would be using to propel their vehicles. As a result of the strong involvement of industry sponsors in the EcoCAR EV Challenge, several sponsors offered to donate propulsion motor systems to teams. Due to this outstanding support, all EcoCAR teams were able to build their first-choice design for propulsion system architecture. American Axle and Manufacturing (AAM) and Magna Powertrain will donate a total of 15 complete electronic drive units to teams, while BorgWarner will be subsidizing the purchase price of 3 complete electronic drive units from the Cascadia Motion catalog. Table II.3.5 shows the final outcomes of the architecture selection process.

Table II.3.5 Architecture Selection Output by Sponsor

Team	Front Unit	Rear Unit
ERAU-BCU	BorgWarner	Cascadia
GT	Magna	Magna
IIT	N/A	Magna
MAC	AAM	Enedym
MSU	AAM	AAM
OSU-WU	Dana	Dana
UA	AAM	Cascadia
UCD	N/A	Magna
UCR	N/A	AAM
UT	Magna	Magna
UWAFT	Magna	Magna
VT	Cascadia	Cascadia
WVU	AAM	AAM

CAV Testing and Technology Demonstration

The competition organizers spent a considerable amount of time this year scoping out the CAV roadmap for the 4-year series. As an outcome of this, the technologies that teams will be developing are novel and currently do not have standardized testing methodologies to execute. To enable the tests of this competition coming in years 3 and 4, the EcoCAR team at Argonne has developed a project plan to build these testing capabilities in-house. In this way, EcoCAR will become a nexus where bleeding-edge research conducted by Argonne can be applied to a fleet of vehicles and tested on-road and/or on-dyno.

EcoCAR EV Challenge Year 1 Winners

Table II.3.6 summarizes the top three overall teams and the teams with the best Project Management, Communications, and DEI programs.

Table II.3.6 Summary of Award Winners from Year 1 of the EcoCAR EV Challenge

Award	Winner
1st Place Overall	OSU-WU
2nd Place Overall	WVU
3rd Place Overall	UA
1st Place Project Management Program	MSU
1st Place Communications Program	UA
1st Place DEI Program	MAC

Conclusions

The EcoCAR EV Challenge includes a very strong emphasis on DEI and mobility equity challenges. As part of this focus, EcoCAR welcomed five new MSIs participating in the series and awarded more than $400,000 in support. The EcoCAR EV Challenge also launched a new embedded DEI initiative for teams that includes an immersive emphasis on DEI and mobility equity concepts for *all* EcoCAR universities. EcoCAR EV Challenge teams also executed a total of 47 youth outreach events for underserved and underrepresented youth reaching a total of 7,637 youth in grades k-12, which also contributes to this DEI priority.

During Year 1, teams also started the vehicle development process, which will continue progressively over the 4-year program. All teams were successful in designing a propulsion system and receiving approval to move forward with that design in the next three years of the program. Most EcoCAR teams received motor drive units from industry sponsors such as AAM, Magna, and BorgWarner to build their chosen propulsion system architecture. Over the course of Year 1, a total of 744 students participated in the program. Students who graduated during FY23 earned more in their first job compared to their non-EcoCAR peers ($5,500-$14,400 on average, depending on major). This salary premium for EcoCAR graduates is evidence of the efficacy of the program in developing the workforce of the future.

All these successes were made possible via the public-private partnerships forged with more than 20 government and industry organizations in support of the EcoCAR program. Together, Argonne and all the EcoCAR sponsors will continue pursuing the mission of training the next generation of engineers.

Key Publications

Every year the EcoCAR program funds multiple positions on each EcoCAR team. This includes engineering graduate research assistants (from multiple disciplines), as well as a Diversity, Equity, and Inclusion Manager, Project Manager, and Communications Manager. Table II.3.7 summarizes the publications produced as a result of this funding during FY23.

Table II.3.7 Publications Authored by EcoCAR EV Challenge Team Members During FY23

Team	Publication/Presentation Title	Author Name	Conference / Journal
ERAU-BCU	Optimizing an Electric Vehicle SUV Powertrain in Different Driving Scenarios	Rachel Abbott	Embry-Riddle Aeronautical University
MAC	EcoCAR Mobility Challenge Electrified Powertrain System, Design, and Integration	Arthur Faron	2023 IEEE Transportation Electrification Conference
MAC	EcoCAR Mobility Challenge Electrified Powertrain System, Design, and Integration	Alex Allca-Pekarovic	2023 IEEE Industrial Electronics Society
MSU	Modeling, power management and control of a RWD and AWD electric vehicle	Aymane Hidara	SAE International Journal of Electrified Vehicles
MSU	Active learning-based pedestrian and road sign detection	Fahmida Islam	2023 SPIE Defense + Commercial Sensing

Team	Publication/Presentation Title	Author Name	Conference / Journal
			Conference
OSU-WU	Development of a Gear Backlash Compensator for Electric Machines in P0-P4 Parallel Hybrid Drivelines	Pranay Ketineni	2023 SAE World Congress
OSU-WU	System Design, Validation, and Implementation of Vehicle-to-Infrastructure (V2I) Communication to Achieve Safe and Efficient Navigation Through Connected Intersections	Karun Prateek Singh	2023 SAE World Congress
UCD	Sliding Mode Wheel Slip Control for Regenerative Braking of an All Wheel Drive Electric Vehicle	Abhigyan Majumdar	2023 IEEE Conference on Control Technology and Applications (CCTA)
UWAFT	Structured Testing Framework for ADAS Algorithm Development	Sachin Fernando	2023 IEEE International Automated Vehicle Validation Conference
UWAFT	Online Identification of Vehicle Driving Conditions Using Machine-Learned Clusters	John Francis Marrone	IEEE Transactions on Intelligent Vehicles
WVU	Powertrain Fuel Consumption Modeling and Benchmark Analysis of a Parallel P4 Hybrid Electric Vehicle Using Dynamic Programming	Jared Diethorn	Journal of Transportation Technologies

II.4 Alternative Fuels Data Center (National Renewable Energy Laboratory)

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Start Date: October 1, 2022 End Date: September 30, 2023
Project Funding (FY23): $1,490,000 DOE share: $1,490,000 Non-DOE share: $0

Project Introduction

The U.S. Department of Energy (DOE) launched the Alternative Fuels Data Center (AFDC) in 1991 in response to the Alternative Motor Fuels Act of 1988 and the Clean Air Act Amendments of 1990. It originally served as a repository for alternative fuel vehicle performance data. Since that time, the AFDC has evolved to become an indispensable resource for fleet managers, fuel providers, policymakers, Clean Cities coalitions, and others working to improve efficiency, cut costs, and reduce emissions in transportation. Armed with the AFDC's data, information, and tools, these transportation stakeholders are increasing the use of domestic alternative fuels and advanced vehicle technologies every year, resulting in substantial benefits to the country's economy, energy security, and environment. The AFDC has achieved this level of engagement because of the many successful public and industry partnerships built in the past 32 years that have contributed to the quality and quantity of information contained on the AFDC website.

Based on expertise from the National Renewable Energy Laboratory (NREL) and partnerships with Argonne National Laboratory (ANL) and Oak Ridge National Laboratory, the AFDC provides extensive information about alternative and renewable fuels, including biodiesel, electricity, ethanol, hydrogen, natural gas, propane, renewable diesel, and other emerging fuels. Users can find out about fuel properties, production, distribution, prices, station locations, emissions benefits, and more. The site features information on the vehicles and engines that use these fuels and the corresponding fueling infrastructure. Fuel-saving strategies like idle reduction, fuel economy improvements, and efficient driving habits are also included on the AFDC.

The site's large suite of online tools and vast collection of vetted data empower fleets and drivers to identify the strategies and technologies that will best help them meet their environmental and energy goals in the most cost-efficient manner. Users can examine long-term trends, estimate costs, project emissions benefits, compare multiple strategies, and identify fuels and technologies that are appropriate for their operational needs and geographic locations.

In sum, the AFDC provides a wealth of information and data on alternative and renewable fuels, advanced vehicles, fuel-saving strategies, and emerging transportation technologies. With interactive tools, calculators, and mapping applications that aid in the implementation of these fuels, vehicles, and strategies, the AFDC functions as a dynamic online hub that enables thousands of stakeholders in the transportation system to interact with one another.

Objectives

The AFDC's primary objective is to be a leading, trusted site that provides information, tools, and resources for transportation decision makers seeking domestic alternatives that diversify energy sources and help businesses and government agencies make wise economic choices. The site also facilitates critical-mass market adoption of alternative fuels and advanced vehicle technologies by fleets and consumers. The AFDC is strategically designed to attract and serve decision makers in all areas of the transportation system, including fuel suppliers, policymakers, Clean Cities coalitions, fleets, and early-adopter consumers. As one of the most visited DOE websites, the AFDC provides a wide range of accurate content that is updated and maintained on a continuous basis through in-depth reviews by subject-matter experts, the identification of changing market conditions, and timely responses to those changes. To ensure the AFDC keeps pace with the rapidly evolving transportation arena, NREL cultivates partnerships with industry leaders and innovators, which fosters intrastate and international collaboration. This enables the AFDC to maintain its position of credibility within the public and private sectors, while continuing to grow its use among key stakeholders.

Approach

The AFDC has become an expert resource because of its approach to producing, updating, and sharing content that is supported by technical expertise in alternative fuels and advanced vehicles. While multiple national laboratory experts are tapped to review new and existing content, the site ensures accuracy and objectivity by relying on close industry partnerships to identify and fill any critical gaps. Behind its user-friendly interface, the AFDC also contains an extensive set of accurate and vetted data. That data is rigorously maintained and presented in an accessible format to ensure target audiences get the information they seek in the most efficient manner possible. Multiple pathways (outlined below) safeguard the effective delivery of credible and objective information and data, which remain the foremost focus of the AFDC's content and tools.

Effective Delivery

Delivering information through a diversified strategy ensures it is easily accessible to people in a variety of formats on a variety of devices. The AFDC approach is to provide information and data in the following ways:

- **Website**: Information and data are accessed directly through the content and tools on the AFDC website. The data is also accessed via referral links from other organizations. Linking to the site as the trusted, third-party, objective resource helps organizations demonstrate that their information or product is developed from vetted, factual information.

- **Application Programming Interface (API)**: Several of the AFDC's datasets are available via an API and are used both internally (to support analysis and tools) and externally by public and private enterprises. API data is delivered from computer to computer and updated automatically on a continuous basis. This kind of data delivery is primarily used by organizations wanting to build their own applications with the data.

- **Data Downloads**: AFDC data is also available for download. Data downloads are most often used by organizations wanting to build applications and load the data into those applications, or by analysts doing research related to alternative fuels.

- **Mobile Apps**: The Alternative Fueling Station Locator is available as a mobile app for iPhone and Android. The AFDC website is also designed to function on various mobile devices, such as tablets and smartphones.
- **Widgets**: Several of the AFDC tools are available as widgets, which are snippets of code that let users embed AFDC content on their websites or blogs. This allows users to include the content in their own websites without the expense of building their own tools.

Depending on the type of organization accessing the AFDC, its business strategy, and use case, any combination of the data sourcing strategies above may be preferred. By offering multiple pathways for using and obtaining information and data, the AFDC provides a valuable service to help organizations meet their policy or business goals. By measuring how the data endpoints are used, NREL can quantify the AFDC's value to the market and industry partners.

Annual Content Review

To ensure the integrity of the information and data, the AFDC undergoes an in-depth annual content review. Each year, subject-matter experts at NREL and ANL conduct a comprehensive review of more than 150 web pages to ensure the AFDC continues to provide accurate, relevant, and up-to-date information for transportation decision makers. This deep dive into the content results in critical thinking about what information is presented and how to continue providing content that helps shape the future of transportation. NREL works closely with other national laboratories, agencies, and industry partners to identify gaps and tap experts for content contributions and reviews.

Results

The AFDC continues to be a relevant and trusted resource. In fiscal year (FY) 2023, the AFDC had more than 9.5 million visitor sessions and 7.2 million unique visitors. Those visitors accessed pages on the AFDC website more than 22.5 million times. Visits to the site included an average of 13.5% returning visitors and 86.5% new visitors.

The AFDC has long been a top-performing website within the Office of Energy Efficiency and Renewable Energy's (EERE) informational portfolio. In fact, about one-third of all EERE website page views are from AFDC pages. Additionally, 11 of the top 30 most-viewed pages in the EERE portfolio are AFDC pages. Figure II.4.1 illustrates the AFDC's traffic in FY 2023. The higher level of traffic between September 2022 and April 2023 was mostly attributed to people looking for information about the electric vehicle tax credit.

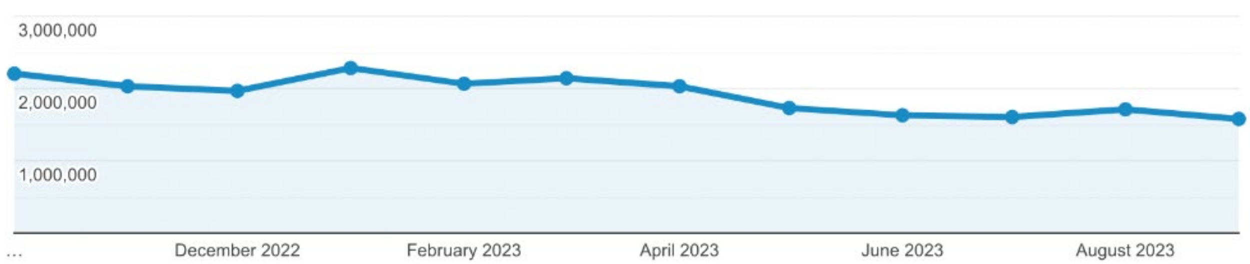

Figure II.4.1 Page views in FY 2023

Referral Quality

The AFDC serves the fleet and transportation industry audience, and one way to measure its effectiveness is to look at the quality and quantity of referrals to the AFDC. (A referral is a website that directly links to AFDC content and tools.) One goal is to gain referrals from sites where the AFDC audience spends time, such as industry websites.

DOE and NREL have been consistently building partnerships with industry and attracting quality referrals for many years. For example, an evaluation of the top 40 referrals in FY 2023 shows that the fleet and industry audiences continue to be the main referral base. In addition, a significant number of visits to the AFDC are direct traffic from fleet and industry audiences (i.e., people in this group who bookmark the AFDC or go directly to known AFDC pages from their browsers, without using a search engine or a link from another website). Figure II.4.2 shows a breakdown of sources of AFDC visits, based on the top 40 referrals.

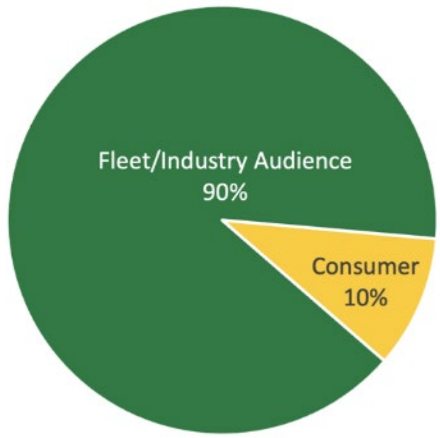

Figure II.4.2 Sources of AFDC visits based on the top 40 referrals

Some of the top referrers in FY 2023 included several vehicle Original Equipment Manufacturer (OEM) sites linking to the laws and incentives information, with Tesla at the top of the OEM list. In FY 2023, the Federal and State Laws and Incentives pages were viewed 6 million times, particularly via referrals from the IRS, FuelEconomy.gov, and numerous vehicle manufacturers related to tax credits and incentives for electric vehicles. During FY 2023, there were more than 14,000 websites linking to the AFDC, resulting in 1.9 million sessions, which indicates the number of times users visited the site after clicking on a link from a referral website. Referrers include companies and organizations of every size and type, such as utilities, major corporations (including vehicle OEMs and equipment manufacturers), small startups, non-profits, cities and states, and search engines. See Table II.4.1 for the top 20 referrers in FY 2023.

Table II.4.1 Top 20 Referrers to the AFDC Website in FY 2023

Referrer	Sessions
irs.gov	428,357
fueleconomy.gov	147,148
shop.tesla.com	101,081
news.google.com	66,204
bmwusa.com	52,940
lyft.com	48,857
subaru.com	48,197
tesla.com	43,278
driveclean.ca.gov	30,895
automobiles.honda.com	28,319
kiplinger.com	28,422
electrek.co	28,909

Referrer	Sessions
ford.com	18,858
cars.com	16,214
greencars.com	15,911
search.usa.gov	23,332
mazdausa.com	14,695
gmc.com	13,821
kia.com	14,161
m.facebook.com	11,973

While referrals are a tangible way to measure part of the AFDC's impact, this metric does not tell the whole story. Referrals provide an idea of how many people see AFDC information on other websites when the organization using the data chooses to link to the AFDC as a source. The referral statistics don't include sites that use AFDC data without a reference link. More importantly, referrals do not quantify how the AFDC data impacts organizations in the transportation industry. For example, the National Conference of State Legislatures (NCSL) depends on the AFDC laws and incentives data to provide a summary of policies by state that promote hybrid and electric vehicles. By relying on this AFDC dataset and the effort that NREL spends researching and disseminating the data, NCSL provides valuable information for its audience while saving significant time and effort that would otherwise be spent collecting the data on its own. DOE and NREL partner with many organizations in the transportation sector to ensure the AFDC datasets provide ongoing value as the market evolves.

AFDC Content Interest

The interest in AFDC data shifts among the tools and fuels over time, depending on policy developments and market economics. By continuously providing the best, most current data and information on all types of fuels and technologies, the AFDC is able to remain relevant, despite changing interests based on trends.

The AFDC contains seven main areas of content based on the alternative fuels defined by the Energy Policy Act of 1992 (EPAct). These content areas include biodiesel, electricity, ethanol, hydrogen, natural gas, propane, and renewable diesel. In FY 2023, interest in fuels and vehicles information accounted for 32% of the total page views on the AFDC. Historical data shows that the most frequently accessed pages by fuel type vary from year to year. In FY 2023, electricity was the most popular topic in terms of page views for fuels and vehicles information with 44% of the total traffic, followed by ethanol with 19% of the total page views.

Figure II.4.3 depicts the breakdown of interest in content by fuel type in FY 2023.

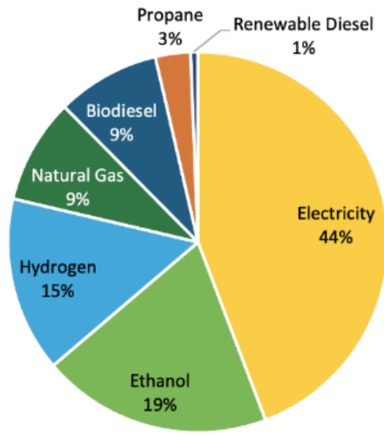

Figure II.4.3 Interest in fuels and vehicles information by subject based on page views in FY 2023

As shown in Figure II.4.4, 49% of the queries for fueling station locations involved electric vehicle charging. This is a significant increase compared to electric vehicle charging's 38% share in FY 2022.

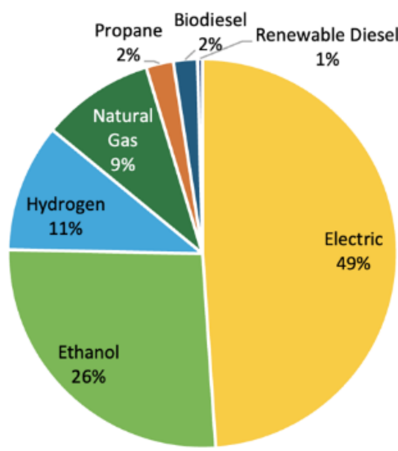

Figure II.4.4 Interest in stations information by subject based on page views in FY 2023

Tools

The tools available on the AFDC range from those that are broad and appeal to multiple audience segments, to specialty tools designed for more focused audiences. The tools directory page [1] received more than 21,000 views in FY 2023; however, a user's discovery of the tools more commonly comes from links on other AFDC pages or referrals from other sites. Direct traffic—meaning visitors that bookmark the page or come to the site without clicking on a link within the AFDC or another site—also provided a significant number of page views for the tools.

Table II.4.2 shows primary tools on the AFDC website by popularity. Notably in FY 2023, the Fuel Properties Comparison tool saw a 53% increase in page views compared to FY 2022. Together, the tools accounted for 69% of the total page views on the AFDC in FY 2023.

Table II.4.2 Page Views for the Primary Tools on the AFDC Website

Tool	FY 2023 Page Views	FY 2022 Page Views	% Change
Alternative Fueling Station Locator	7,579,874	8,179,961	-7%
Laws and Incentives Search	6,050,049	5,877,881	3%
Maps and Data Search	1,158,163	1,023,364	13%
Vehicle Search	421,244	642,319	-34%
Vehicle Cost Calculator	414,426	822,460	-50%
State Information Search	95,489	101,751	-6%
Case Studies Search	53,392	53,387	0%
Fuel Properties Comparison	50,747	33,097	53%
Publications Search	42,391	38,769	9%
EVI-Pro Lite	38,805	38,048	2%

Several of these tools are available as widgets that allow users to embed the tools on their own websites. In FY 2023, the Alternative Fueling Station Locator widget was the most popular widget, with more than 1 million page views while embedded on other websites, accounting for 14% of the total stations traffic.

Data, APIs, and Downloads

A significant growth area for the AFDC has been sharing data and tools with a wider audience. Table II.4.3 summarizes the data activity in FY 2023 by showing the total number of API requests (people searching or using the dataset on other websites or systems), the number of unique API users, and the number of data downloads, which are offered on the data downloads page [2] and provide a snapshot of various data offerings at any point in time.

Table II.4.3 API Requests, Users, and Downloads in FY 2023

Data	API Requests	Unique API Users	Downloads
Alternative Fueling Stations	20,986,125	10,281	6,356
Laws and Incentives	126,754	62	4,704
Vehicles	54,265	84	2,763

Stations data downloads and API requests have expanded the use of AFDC data over time. The alternative fueling stations API (a live data feed of stations data) received more than 20 million requests in FY 2023.

The laws and incentives API received more than 126,000 requests in FY 2023. Many OEMs now link to the laws and incentives site. This is an opportunity for outside users to filter the laws and incentives data using the API, which increases the value of their own websites.

Beyond data downloads, the most downloaded document on the AFDC in FY 2023 was the fuel properties comparison chart, with more than 25,000 downloads. The high-resolution images for vehicle illustrations had more than 400,000 downloads.

Conclusions

The AFDC provides robust and relevant information to advance the goals of DOE's Vehicle Technologies Office, as is evident by the fact that user engagement on the site continues at a high level every year, with an increasing number of referrals from public and private industry. This underscores the need for credible, objective, third-party data and information in the growing market for alternative and renewable fuels and advanced vehicles. Through thoughtful management and many partnerships, the AFDC helps ensure that the content and tools are relevant and reach the right audience, by providing information and data in a variety of formats, including web applications, APIs, data downloads, and embeddable widgets. This valuable resource continues to lead EERE websites as a content provider and forward-thinking driver of data and tools to help people find transportation solutions.

Key Publications

AFDC home page: afdc.energy.gov

Alternative Fueling Station Locator: afdc.energy.gov/stations

Laws and Incentives Search: afdc.energy.gov/laws

Maps and Data Search: afdc.energy.gov/data

Vehicle Cost Calculator: afdc.energy.gov/calc

Vehicle Search: afdc.energy.gov/vehicles/search

Publications Search: afdc.energy.gov/publications

State Information Search: afdc.energy.gov/states

Case Studies Search: afdc.energy.gov/case

Fuel Properties Comparison: afdc.energy.gov/fuels/properties

EVI-Pro Lite: afdc.energy.gov/evi-pro-lite

Data Downloads: afdc.energy.gov/data_download

Widgets: afdc.energy.gov/widgets

Developer APIs: developer.nrel.gov/docs/transportation/alt-fuel-stations-v1

References

[1] afdc.energy.gov/tools

[2] afdc.energy.gov/data_download

II.5 EPAct Regulatory Programs (National Renewable Energy Laboratory)

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Start Date: October 1, 2022 | End Date: September 30, 2023
Project Funding (FY23): $736,767 | DOE share: $736,767 | Non-DOE share: $0

Project Introduction

The National Renewable Energy Laboratory's (NREL's) Transportation Technology Integration group, within the Center for Integrated Mobility Science, provides technical and analytical support to the Vehicle Technologies Office's (VTO's) Alternative Fuels Regulatory activity, which is mandated by federal legislation. Specifically, NREL supports DOE's implementation of Sections 507(o), 501, and 508 of the Energy Policy Act of 1992 (EPAct) through the provision and management of information products and other technical, program, policy, and regulatory analyses. EPAct Sections 507(o) and 501 mandate that covered state and alternative fuel provider fleets (respectively) acquire alternative fuel vehicles (AFVs) as specific percentages of their new light duty vehicles. EPAct Section 508 requires DOE to establish a vehicle credit trading program to provide compliance flexibility to covered fleets. In Fiscal Year 2023, NREL's work focused on two areas: State and Alternative Fuel Provider program support, and rulemaking and regulatory activities. In addition to project management and operational functions, NREL's role is to analyze, make recommendations and implement means to streamline this congressionally mandated program. NREL also integrates work across several related alternative fuel programs to leverage resources and ensure that researchers have access to the latest developments and knowledge within related DOE research and development programs.

Objectives

The key overarching objective is to ensure full implementation of the statutorily mandated program and oversee compliance by covered entities. Within this objective there are two tasks, as follows:

Task 1: Implement legislative requirements for State and Alternative Fuel Provider (SAFP) fleets. The core activities in this task involve tracking and ensuring fleet compliance, analyzing, and implementing any new legislative requirements and policies that may impact the program, and working directly with fleets, as needed, to ensure compliance. NREL developed and maintains an online reporting system and the vehicle acquisition and fleet compliance database to support this task.

Task 2: Support DOE's rulemaking activities. Tasks have included analysis and development of a revised national replacement fuel goal; development and promulgation of DOE's final private and local fleet rule determination; and development of rules to implement statutory requirements set forth in EPAct, as amended by EPAct 2005 and the Energy Independence and Security Act (EISA) of 2007. At times, support for rulemaking also requires evaluating proposed legislation that may impact SAFP fleets, and developing technical comments and suggested revisions, for communication to Congress through DOE's legislative affairs offices. This may include reviewing provisions that affect the availability and cost of vehicles, technology, and fuels; potential fuel savings; and programmatic requirements. NREL also addresses, as necessary, fuel petition review and analysis.

Approach

NREL's Transportation Technology Integration group works to increase the use of alternative fuel vehicle technologies. The NREL team provides technical and analytical support to VTO's Alternative Fuels Regulatory activity, which implements elements of federal legislation related to the acquisition of alternative fuels and advanced fleet vehicles. This involves providing VTO with strategic planning, project management, and collection and management of program data, as well as technical, regulatory, and analytical support of the program.

NREL has developed an integrated outreach and compliance assistance system consisting of support personnel, online program information, online reporting tools for fleets, and a database of compliance data, which has served as a repository of vehicle and fleet data since the inception of the program. NREL's strategy provides timely and accurate information to fleets and streamlines the reporting process, which ensures maximum fleet compliance, while limiting administrative burden. NREL frequently reviews and updates online information and tools as well as performing routine maintenance and archiving of program data.

Results

Covered fleets report at the end of a calendar year for the preceding Model Year (MY), e.g., the reports submitted by December 31, 2022, covered MY 2021 vehicle acquisitions. In reports submitted at the end of 2022, the compliance rate for the State and Fuel Provider program for the more than 300 reporting entities, representing approximately 2,000 covered fleets, was 100%.

The program provides tremendous flexibility in terms of how fleets may achieve compliance, whether they select Standard Compliance or Alternative Compliance. Fleets complying via Standard Compliance may earn credits toward compliance if they acquire light-duty AFVs, purchase and use biodiesel, acquire hybrid vehicles, neighborhood electric vehicles, and medium and heavy-duty AFVs, and/or invest in alternative fuel infrastructure, non-road equipment, and emerging technologies related to electric drive vehicles. In FY 2023, the program received and analyzed results from MY 2022 reports. More than 300 fleets used Standard Compliance and exceeded their aggregate MY 2022 acquisition requirements by 20%. Fleets complying via Alternative Compliance do so by reducing petroleum consumption in any number of ways, including through the use of alternative fuels, buying more efficient vehicles, implementing a telecommuting program, reducing trips made, or implementing other efficiency measures. The six covered fleets that used Alternative Compliance exceeded their aggregate MY 2022 petroleum use reduction requirements by more than 40%.

Covered fleets may earn credits for acquiring more AFVs than are required for compliance; those credits can be banked for future use in complying with EPAct requirements. Covered fleets may also meet up to half of their acquisition requirements by using biodiesel fuel. Fleets reporting biodiesel usage report amounts that typically exceed the amount of biodiesel that could be counted toward credits. The amount of biodiesel use reported increased from almost 12 million gallons in MY 2021 to over 12.5 million gallons in MY 2022. Unsurprisingly, DOE also saw an increase in total biodiesel credits earned, with fleets earning a total of 1,893 credits in MY 2022 for using biodiesel, an increase from 1,426 credits earned in MY 2021. The divergence in the reported amount of biodiesel used and the number of biodiesel credits earned is due to fleets reporting more biodiesel than that for which they actually earn credits (i.e., fleets may earn credits for only up to half of their acquisition requirements).

Fleets reported an increase in the number of reported creditable light-duty vehicles acquired (9,077) in MY 2022, which includes light duty AFVs, non-AFV hybrid-electric vehicles (HEVs), and neighborhood electric vehicles (NEVs), when compared to MY 2021 (7,905). MY 2022 marked the ninth year that fleets complying via Standard Compliance could earn credits for acquiring an expanded range of vehicles, including HEVs and NEVs, and for investing in alternative fuel non-road equipment, alternative fuel infrastructure, and emerging technologies. Covered fleets earned 1,162 credits for partial-credit vehicles and 349 credits for investments in alternative fuel infrastructure and non-road equipment in MY 2022 (a slight increase for the three categories combined, over MY 2021 [1022]).

Conclusions

The data for MY 2022 demonstrated 100% compliance by all entities within the program, and the extent of over-compliance suggests an ongoing interest on the part of EPAct-covered state and alternative fuel provider fleets in supporting the AFV and advanced technology vehicle markets.

II.6 Technical Assistance/Technical Response Service (National Renewable Energy Laboratory)

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Start Date: October 1, 2022 End Date: September 30, 2023
Project Funding (FY23): $1,225,000 DOE share: $1,225,000 Non-DOE share: $0

Project Introduction

The National Renewable Energy Laboratory (NREL) leads a group of in-house and contracted experts to provide technical assistance and information across transportation technologies to a wide cross section of stakeholders. The Technical Assistance project and Technical Response Service connect transportation stakeholders with objective information that informs decision making, smooths integration, reduces risk, and helps ensure alternative fuels, electric vehicles, and advanced vehicle technology projects are conducted efficiently and cost effectively. These efforts can also identify information and technology gaps and inform research to improve fuels and advanced vehicle technologies, with industry and consumer needs in mind. Across the nation, fleets, states, and cities of all sizes continue integrating alternative fuels, electric vehicles, advanced vehicle technologies, and efficiency improvements into their operations. These changes have reduced transportation energy costs, improved resiliency, contributed to improved air quality and greenhouse gas reductions, transformed fleet managers and vehicle operators into sustainability leaders, and helped communities make changes today and plan for the future. Yet as they evaluate their options to use alternative fuels, electric vehicles, and advanced vehicle technologies, these users and managers frequently need additional information or expert guidance to plan the transition, identify solutions that meet their needs, make informed decisions, and overcome technical issues they encounter. Similarly, policymakers, analysts, and other transportation decision makers need objective information from expert sources to inform research investment, incentive programs, and projects. To address these challenges, the U.S. Department of Energy's (DOE) Vehicle Technologies Office (VTO) provides technical assistance that connects stakeholders with experts who can provide objective information, and answer questions about and assist with alternative fuels, electric vehicles, efficiency improvements, and other emerging transportation technologies. The type of technical assistance provided (or requested) runs the gamut, from fielding one-time questions that can be answered with information and a list of resources to in-person assistance from a subject matter expert on how a particular technology functions. Technical assistance also helps with planning, implementation, and operational challenges facing end users. Through these trusted and proven methods, DOE has helped fleets, communities, and other stakeholders make informed decisions to deploy hundreds of thousands of alternative fuel vehicles (AFVs), electric vehicles, and the fueling and charging infrastructure that support them to serve a growing market. The project is continually evolving to identify and tackle the most pressing integration barriers, contribute new expertise, and inform emerging technology research and deployment needs.

Objectives

The objective of the Technical Assistance project is twofold. First, it directly assists end users by providing a conduit to information and expertise that enables informed decisions, proactively pursues solutions, and helps solve problems. Second, it provides critical feedback to support next generation research and transportation technologies. This is accomplished by employing a few key methods:

- Providing unbiased information, resources, and assistance to a broad base of transportation stakeholders, by sharing and applying practical real-world experience, lessons learned, and best practices.
- Securing in-house (across national laboratories) and subcontracted experts that provide a range of expertise across fuels, vehicle types and technologies, and identifying additional technical experts as new technologies emerge in the marketplace.
- Maintaining robust knowledge of the alternative fuels industry and monitoring inquiry topics, to identify knowledge and integration challenges and barriers that should be addressed.
- Using results to guide Technical Assistance objectives and inform future research and development efforts.

Approach

The Technical Assistance project makes varying levels of technical assistance available, ranging from email exchanges that connect stakeholders to existing online tools and documents, to in-person consultations that address specific in-depth challenges. NREL assigns inquiries to appropriate in-house and subcontracted experts, based upon the type of assistance requested and the required depth of response. As appropriate, NREL collaborates with fellow national laboratories to identify solutions and provide the needed level of expertise. Additionally, Technical Assistance can be either reactive, to respond to an urgent challenge in real-time, or proactive, to collect knowledge, inform technical guidance such as codes & standards, and update or develop resources that address current or emerging issues.

NREL offers a base level of Technical Assistance through the VTO Technical Response Service (TRS). NREL subcontracts the TRS activity through a competitive process which was last conducted in FY23. The TRS is a phone- and email-based service staffed by seasoned experts who help stakeholders find answers to technical questions about alternative fuels, electric vehicles, fueling and charging infrastructure, efficiency improvements, idle-reduction measures, advanced vehicle technologies, and other related resources. TRS representatives are experienced with a broad range of resources including online tools and calculators, state and federal laws and incentives, peer-reviewed research, academic publications, program-accumulated case studies, industry trends, and lessons learned. While much information is available on a variety of VTO and other websites, there is still significant demand for assistance that addresses individual questions or that rapidly connects people with critical information when needs arise. The TRS helps clients focus on and access resources that address their situations and increases their familiarity with relevant resources. Upon receiving an inquiry, TRS experts provide a tailored response by curating a list of current, relevant resources and pinpointing the applicable material within those resources, on a case-by-case basis. Each inquiry is documented in a database, and through analytics, DOE can identify trends and information needs. The TRS is an important resource that answers inquiries, but it also enables VTO to identify information gaps, technology shortfalls in the field, and other technical topics that need to be addressed. Constant attention to evolving topics ensures the TRS staff are well informed and able to field the majority of incoming queries.

For inquiries that require specific expertise or technical investigation, DOE provides technical assistance through Tiger Teams, a group of skilled experts from national laboratories and industry. NREL identifies industry experts through a competitive process and subcontracts with them. These experts have deep knowledge, either in a specific area, or across the range of alternative fuels, including electricity, natural gas, hydrogen, propane, and biofuels, such as ethanol and biodiesel. With many years of hands-on experience, these experts work with fleet operations staff, fuel providers and fueling equipment suppliers, vehicle conversion companies, and equipment and vehicle manufacturers, to assist with all phases of a project. From concept to implementation, operation, and maintenance, Tiger Teams help fleets, municipalities, and industry make informed decisions and tackle difficult technical and implementation challenges. Building on extensive experience, Tiger Teams help stakeholders achieve better results, more quickly and cost-effectively. Designed to not compete with private industry, Tiger Team experts come alongside existing project teams in situations that challenge local resources, or in instances where local expertise does not exist. Acting as a neutral third-party, Tiger Teams provide technical expertise, help address problems, resolve differences, and get stalled projects moving again.

Results

Technical Response Service Inquiries

A robust system allows each inquiry to be tracked, which also means trends can be identified. Throughout this fiscal year, available funding and incentives were a central focus of inquiries. Requests included: Inflation Reduction Act tax credit eligibility, National Electric Vehicle Infrastructure (NEVI) Formula Grant Program and Buy America requirements for electric vehicle (EV) charging stations, and queries related to EV charging infrastructure including procurement best practices, siting and design recommendations, and infrastructure costs. Hydrogen fueling station locations and infrastructure also generated interest among users.
A sampling of TRS inquiries includes the following:

A Clean Cities coalition staffer in support of a local stakeholder inquired about the emissions benefits of E15 compared to E10. The TRS referred to the Alternative Fuels Data Center (AFDC) E15 page, explaining that stations are not required to sell E15, but some have started offering E15 due to state and federal incentives for upgrading equipment, and improved profit margins. TRS noted a recent California Air Resources Board study that compares the emissions from California reformulated E15 to E10, and a report that evaluates the greenhouse gas emission benefits of E15 in California through 2040.

A Clean Cities coalition staffer asked about case studies and funding opportunities related to sustainable aviation fuel (SAF), and information about SAF pathways that are commercially available. The TRS provided links to the multiagency SAF Grand Challenge Roadmap, which states that lipid-based pathways are expected to be the primary fuel pathway leading up to 2030. For information on SAF federal incentives, the TRS pointed to relevant Inflation Reduction Act incentives and recommended the National Renewable Energy Laboratory's SAF Today podcast.

A Clean Cities coalition director inquired about regulations for disposing of a damaged EV battery, the risk of EV battery fires after a crash, safety instructions for EV drivers and battery capacity at end of life for EVs. The questions arose during a technical training session the coalition hosted for sales associates at a local dealership. The TRS explained that recommended protocols for handling damaged batteries vary based on the speed and severity of the accident. The TRS quoted post-crash battery assessment and disposal recommendations from the National Highway Traffic Safety Administration (NHTSA) and the National Transportation Safety Board. The TRS referred to information from the National Fire Protection Association (NFPA) about post-crash battery fires and provided NHTSA’s Interim Guidance for Electric and Hybrid-Electric Vehicles Equipped with High Voltage report. The TRS stated that current industry standards suggest that batteries provide useful life in EVs until the usable capacity degrades to 80% and explained that Lawrence Berkeley National Laboratory is evaluating this assumption. The TRS also noted that actual battery lifespans will vary depending on several factors.

A Clean Cities coalition director inquired about variables impacting the total cost of ownership (TCO) analysis for electric and compressed natural gas (CNG) school and transit buses. The TRS stated that the major factors impacting the TCO for buses are the vehicle purchase price, fuel prices, and infrastructure costs. The TRS discussed the regional factors that may impact a TCO analysis, such as the cost of fuel and fuel efficiency during cold weather operation. For electric school and transit bus cost resources, the TRS pointed to resources from Argonne National Laboratory (ANL), NREL, World Resources Institute, and California transit agencies. For CNG bus cost resources, the TRS referred to an AFDC case study and Hillsborough Area Regional Transit Agency presentation on CNG bus purchases.

A Clean Cities coalition director asked for resources on renewable natural gas (RNG) and renewable propane as well as for an explanation of the Renewable Fuel Standards (RFS) renewable identification number (RIN) system. For general information on RNG, the TRS linked to the AFDC RNG production webpage, the U.S. Environmental Protection Agency's (EPA) RNG webpage, and ANL's RNG for Transportation Frequently Asked Questions (FAQs) document and for renewable propane resources recommended the AFDC Propane Production and Distribution webpage and the Propane Education & Research Council website. The TRS provided an overview of the EPA's RFS program, explaining how the EPA tracks compliance with the program through the RIN system.

A Clean Cities coalition staffer asked how to determine the carbon emissions reduction achieved per dollar when transitioning from diesel to renewable diesel (RD) or electric power for heavy-duty (HD) vehicles. Based on subject matter expert input, the TRS recommended the World Bank article, What You Need to Know About Abatement Costs and Decarbonization, for a formula to calculate the abatement costs. The TRS also suggested using ANL's Alternative Fuel Life-Cycle Environmental and Economic Transportation (AFLEET) tool.

A National Energy Technology Laboratory representative asked for example codes or policies to help a municipal solid waste department navigate questions from an Authority Having Jurisdiction about fire codes relative to EVs charging in an enclosed garage. Using input from NREL, the TRS explained it is important to understand what code and what version of the code the AHJ is citing and what their major concerns are. The TRS recommended the NFPA EV Community Preparedness Online Training Code Official Edition course, which educates code officials on EVs and establishing electrically safe working conditions. For codes and standards typically used for U.S. EV and infrastructure projects, the TRS referred to NREL's EV and Infrastructure Codes and Standard Citations document.

A representative from a large U.S. research university inquired about the annual amount of biogas/RNG produced by the agriculture sector in the U.S. and used for transportation purposes. For a comprehensive list of biogas projects that are upgrading gas for pipeline injection or use as vehicle fuel in the United States, the TRS suggested ANL's RNG database. The dataset is organized by feedstock (e.g., livestock and agricultural) and contains additional information about the type of fuel produced by each project (e.g., vehicle fuel, pipeline). The TRS suggested other sources of biogas production figures from the agriculture sector: the U.S EPA's AgSTAR Data and Trends page and AgSTAR livestock anaerobic digester database.

A federal government representative (as part of a DOE controlled correspondence) asked for a point of contact to discuss the installation of workplace EV charging equipment on a U.S. Department of Defense property. The TRS recommended using the webform on the Federal Energy Management Program (FEMP) Technical Assistance page or contacting the FEMP Sustainable Fleet Management team. For general information and guidance on the FEMP program, the TRS recommended reviewing FEMP's EVs for Federal Fleets page and Federal Workplace Charging Program Guide.

A representative from a major logistics company asked about data available in the AFDC Station Locator, specifically, how to identify CNG fueling stations with a renewable source on-site and asked for field values under "CNG Renewable Sources". The TRS referred to the AFDC data included in the Alternative Fuel Stations Download and explained that the field "CNG Renewable Sources" indicates the type of biogas used to generate CNG on-site, if renewable CNG is dispensed at this site. The TRS provided a list of definitions for the "CNG Renewable Sources" field and indicated that a blank record for this field indicates the station does not dispense RNG.

A representative from a U.S. based non-profit international advocacy group requested data from the AFDC Station Locator for 2021 and 2022 that include the number of EV charging stations per 100,000 individuals, categorized by state. The TRS noted that the AFDC does not track historical EV charging station data per 100,000 people. For historical data on EV charging station counts by state, the TRS attached a spreadsheet with monthly data from June 2007 to March 2023. To calculate EV charging stations per capita, the TRS recommended dividing the number of EV stations in each state in the provided spreadsheet by population data from the U.S. Census Bureau.

A fire chief from a small fire department in Texas asked for information on the environmental and safety requirements for hydrogen fueling station development, because the department is preparing for the installation of a hydrogen fueling station. The TRS pointed to the Hydrogen Safety, Codes, and Standards section of the AFDC Hydrogen Fueling Infrastructure Development webpage, noting that many of the hydrogen safety codes and standards today are based on practices from the chemical and aerospace industries. The TRS explained that DOE is coordinating the efforts of codes and standards organizations to develop more robust codes and standards that ensure the safe use of hydrogen for transportation and stationary applications. For more information on hydrogen safety, codes, and standards, the TRS recommended the DOE Hydrogen and Fuel Cell Technologies Office Safety, Codes and Standards website.

A journalist from a convenience store industry publication inquired about the pros and cons of battery-based EV charging. The TRS explained that the use of stationary energy systems for EV charging is a relatively nascent technology. They noted that most research concerning EV charging and stationary energy storage systems seeks to understand how such systems can be integrated with the grid and other technologies, such as smart chargers and photovoltaic systems, for peak shaving, load shifting, and/or cost reduction. The TRS pointed to research from NREL, ANL, and Idaho National Laboratory that explores how energy storage systems can alleviate the grid impact of EV charging during peak hours.

A major medium-heavy duty engine Original Equipment Manufacturer (OEM) representative asked what companies are certified to conduct bonfire tests for CNG tanks. The TRS, following input from NREL, recommended contacting CNG tank manufacturers to identify companies that are certified. The TRS stated that the CSA Group offers CNG certification and training programs which cover the bonfire testing process. The TRS also referred to Natural Gas Vehicles for America for a list of fuel system inspector training and certification programs.

A representative from a major OEM inquired about which states regulate the sale of electricity from public EV chargers, and specifically which states regulate sales based on kilowatt hours or sales by the minute. The TRS offered recommended search parameters for the AFDC Laws and Incentives database to identify states with EV charging station billing requirements and noted that California is the only state that has prohibited pricing by the minute. The TRS included additional search parameters to identify states that allow EV charging service providers to sell charging services on a per kWh basis without being subject to public utility regulations. Additional information included DOT's Federal Highway Administration minimum standards and requirements for federally funded EV charging infrastructure projects in a Final Rule, specifically Section §680.116 which includes requirements for pricing structures.

A representative from a family-owned meat processing company asked how many gallons of beef tallow or soybean oil is required to produce one gallon of renewable diesel. Based on feedback from NREL experts, the TRS noted that one tonne of waste oil produces 0.9 tonnes of liquid fuel. The TRS recommended reviewing the Bioenergy Technologies Office's Biofuels Techno-Economic Analyses Database which provides data on biofuel production yields and suggested exploring the U.S. Department of Agriculture's Bioenergy Statistics for data on plant-level renewable diesel production.

A state DOT representative, in updating the state's travel demand model, reached out for fuel economy data for passenger vehicles, single-unit and multi-unit trucks. The TRS shared fuel efficiency data for passenger vehicles from FuelEconomy.gov's Resources page but did not have a similar comprehensive dataset for single-unit and multi-unit trucks. For medium- and heavy-duty fuel economy data by vehicle type, the TRS recommended referring to the default fuel economy values in AFLEET. For more fuel economy assumptions for medium- and heavy-duty vehicles, the TRS pointed to the ANL publication, Comprehensive TCO Quantification for Vehicles with Different Size Classes and Powertrains.

A utility representative inquired about EV charging assumptions used in the Electric Vehicle Infrastructure Projection (EVI-Pro) Lite tool and whether they can use the weekday and weekend profiles in EVI-Pro Lite to create an 8,760-hour load profile. The TRS provided an attachment with the EVI-Pro Lite tool assumptions and pointed to specific sections pertaining to EV charging. The TRS, based on feedback from NREL, noted that it is possible to stitch together weekday and weekend load profiles in EVI-Pro Lite to create an 8760-hour load profile, noting they should correct for any seasonal variations in temperature. To do so in EVI Pro Lite, the TRS suggested changing the Average Ambient Temperature field and the Average Daily Miles Traveled field.

Technical Assistance Activities

Technical assistance or Tiger Teams requests are identified through the work of the TRS and through direct outreach to NREL staff through email or the Clean Cities or AFDC websites. Additionally, NREL is proactive in identifying Technical Assistance opportunities through training. Some examples of FY23 Technical Assistance include:

Multiple stakeholders expressed the need for more information about EV battery fires and electric vehicle fires. Audiences included fleet managers, technicians, and first responders. To further identify current concerns and informational needs, NREL connected with stakeholders, and with NHTSA and the International Association of Fire Chiefs to better understand EV fires, identify potential resources, discuss opportunities for collaboration, and develop proactive and reactive support for stakeholders and Clean Cities coalitions. NREL will publish an EV Fires fact sheet early in FY24. The fact sheet will be a resource for a broad set of stakeholders, including Clean Cities coalitions, and will be used to support Joint Office technical assistance.

Four first responder training sessions occurred as the result of a collaboration with an OEM, Colorado Department of Transportation, and NREL. Approximately 300 first responders from the Denver metropolitan region and throughout Colorado attended the training, which NREL attended. NREL also attended a first responder training session in Alabama conducted by a private company. Attendance at these training sessions enables NREL to establish broad insights into information needs and identify additional workforce development, training, and other resource needs. NREL also created an online AFDC resource that will be published early in FY 24 that outlines available third-party training resources for first and second responders responding to alternative fueled vehicle incidents, particularly those involving EVs and hybrid-electric vehicles.

NREL attended EV transit bus technician training courses led by transit OEMs. NREL's attendance was instrumental in educating the core technical assistance team on key aspects of bus high-voltage systems. Attendees provided information about technician concerns, real-world experiences, and workforce development needs identified by fleets adopting electric transit buses. NREL will use this information to help scope future technical assistance activity. NREL learned that more comprehensive training and refresh courses are needed for technicians who will be servicing the high-voltage systems.

NREL hosted the Natural Gas Vehicle Technology Forum (NGVTF) in January 2023. The forum is a long-standing avenue for the natural gas industry to share information about natural gas R&D projects and discuss the barriers impacting forward progress in the industry. Participants also hear about updates on codes and standards work, along with how adjustments to these codes and standards can help to address concerns and minimize duplication and conflicting requirements. In 2023, the forum also included a discussion of hydrogen as a fuel for internal combustion engines, and challenges for high volume heavy-duty truck use.

NREL continued to provide technical assistance to a major OEM wheel supplier (identified in the 2022 Annual Progress Report) that was experiencing fuel system problems in its propane forklifts in the United States. NREL focused on why operations in the U.S., but not Japan, were being impacted, also noting that most propane-fueled forklifts use fuel systems manufactured outside the U.S. Results from the fuel analysis suggested the propane needed to be filtered HD5 grade propane, which is what is used in Japan. The manufacturer has taken steps to use a filtered propane product to solve the operational problem.

A small school district in Texas is an early adopter and proponent of EV school buses. To understand and address operational challenges, the Technical Assistance team at NREL is routinely proactive in collecting information about vehicle operations from fleets. NREL participated in a listening session with the district to learn how the buses were operating. The district detailed their successes and how they had addressed challenges.

A school district in rural southern Colorado was awarded rebates for two school buses through the EPA Clean School Bus program. The local fire chief raised questions about fire safety and first responder training once the buses were in operation. NREL, Drive Clean Colorado, Colorado Department of Public Health and Environment and the local utility for the school district attended a school board meeting to understand and address community concerns. Attendees provided numerous comments and NREL provided technical information about bus operations, high voltage systems, first responder and other training, and offered training support for the fire chief and first responders.

Codes and standards work continues to be part of the technical assistance NREL provides. NREL initiated review and analysis of the primary standards associated with emergency response and electric vehicles—SAE J2990, ISO 17840-1, and ISO 17840-3. The goal of this work is to understand current protocols and help improve the tools that first responders are using in the field to assess alternative fuel vehicles, fight fires, aid occupants, and transport incident vehicles in a safe and efficient manner.

Electric school bus (ESB) operation continues to be a topic of significant interest. Technical assistance requests related to ESBs illustrated a need for real-world data on vehicle performance. Fleets considering electric require reliable real-world performance and efficiency data to evaluate how ESBs could serve their existing conventional vehicle routes. To address this need, NREL established a project to install data loggers on a mix of electric, propane, diesel, and gasoline buses at a Denver area school district and at a school district in northwest Colorado. As part of the project NREL developed a data processing and analysis practice for the ESB data, which will streamline future efforts and provide school districts with a baseline analysis of real-world ESB efficiency. Additional data will allow a better understanding of different routes and accessory load requirements.

Clean transportation workforce development, particularly related to electric vehicles and charging infrastructure, has emerged as an area of significant interest. NREL hosted listening sessions with several Clean Cities coalitions this year to gain insights on workforce development initiatives and challenges associated with vehicle maintenance and charger installation and maintenance. Through these sessions, NREL identified substantial geographic variation in available training programs and confirmed potential training and workforce availability gaps, particularly for heavy-duty vehicles as well as charger installation and maintenance.

II.7 Technologist-in-Communities (National Renewable Energy Laboratory)

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Start Date: October 1, 2022 End Date: September 30, 2023
Project Funding (FY23): $1,200,000 DOE share: $1,200,000 Non-DOE share: $0

Project Introduction

As cities around the country launch efforts to use data and mobility technology in more innovative and effective ways than ever before, Smart Cities are serving as living laboratories for increasing the energy efficiency and reducing the emissions of urban mobility systems, while increasing the effectiveness of mobility services. The U.S. Department of Energy (DOE) Energy Efficient Mobility Systems (EEMS) Program collaborates closely with the Technology Integration (TI) Program and envisions an affordable, efficient, safe, and accessible transportation future in which mobility is decoupled from energy consumption. Technologies that may help achieve this vision include advanced mobility systems that are automated, connected, efficient, and shared (ACES) and fully integrated across modes. EEMS and TI support research, development and deployment activities that advance such technologies and other opportunities to increase mobility energy productivity [1] in communities.

As a part of an interagency memorandum of understanding, DOE and the U.S. Department of Transportation (DOT) are working together to accelerate innovative smart transportation systems research. Through this coordination, DOE paired Technologist in Cities (TIC, retitled in 2021 as “Technologist in Communities” to better reflect the size range of community partners) with Columbus, Ohio, after the City of Columbus’ Smart Columbus project won the DOT Smart City Challenge in 2016. The TIC has worked with the city and its partners throughout the life of the Smart Columbus project, beginning in 2016, continuing through FY 2022 in a reduced capacity as the Smart Columbus project transitions to a subsequent phase.

The Smart Columbus initiative was supported by two grants, totaling $50 million. A $40-million DOT grant supported multiple projects, including smart mobility hubs, automated electric shuttles, enhanced communications such as dedicated short-range communications, and truck platooning. Complementing the DOT grant was a $10 million grant from Paul G. Allen Philanthropies (formerly Vulcan) to accelerate adoption of plug-in electric vehicles, enhance charging infrastructure to support plug-in electric vehicle adoption, and provide a cleaner and more efficient electric grid. Smart Columbus has completed the initial grant activities, and has refocused into phase 2, integrating the work of the initial phase of funding with new initiatives informed by community stakeholders that include stronger focus on communication technologies, quality of life, and equity improvements. Although delayed by the COVID-19 pandemic, Smart Columbus 2.0 is well underway, continuing to provide leading practice for Smart City implementations.

The TIC program has since grown beyond Columbus, to engagements in a range of settings, expanding its liaison and support functions to serve additional Smart Community initiatives. These initiatives span rural projects seeking to enhance mobility/energy solutions; cities with significant disadvantaged communities such as St. Louis, Missouri; Baltimore, Maryland; and Cleveland, Ohio; the New York State Energy Research & Development Authority (NYSERDA) Clean Transportation prizes; and activities in various other communities seeking to leverage ACES technologies for equitable and energy-efficient mobility solutions.

Objectives

In FY 2023, the TIC continued to reach out and engage with an increasing number of communities, serving as a liaison on energy and mobility issues and expanding into other topic areas. This culminated in site visits to key locations, including the inaugural TIC scanning tour to Dallas and Arlington, Texas; Phoenix, Arizona; western Puerto Rico; and Columbus, Ohio. These visits facilitated information finding, observation, and feedback between DOE's EEMS and TI research programs and project activities at multiple locations to inform modeling, data analysis, and demonstrations conducted in collaboration with national laboratories. Activities in these locations include on-demand transit, automated ride-hailing, micromobility, airport ground mobility, rural mobility and microgrid interconnections, and rapidly emerging high-tech production facilities. The TIC objectives in all these initiatives are to encourage and support deployments of technologies that improve energy efficiency, inform mobility equity strategies, and lead to a more sustainable transportation system. The TIC strives to act as a liaison between communities and the DOE and national laboratories information resources and technical expertise, as well as to provide data and lessons learned that can be subsequently used to further research and assist other Smart Community initiatives.

Approach

TIC support of Smart Community and other emerging initiatives includes a variety of activities, methods, and approaches, as outlined below:

- Maintain a direct presence with partners/collaborators at adequate frequency to develop and sustain working relationships and serve liaison roles.
- Provide access to DOE and national laboratory resources as appropriate to meet needs within the Smart Community portfolio of projects and interests.
- Advocate for energy metrics and performance measures as part of Smart Community efforts and assist in the implementation of such metrics through case studies and demonstrations.
- Encourage data sharing, innovative uses of data, and access to critical data streams associated with advanced mobility, such as connected/automated vehicles, automated electric shuttle demonstrations, automated mobility districts, on-demand transit, and micromobility using such tools as the Mobility Energy Productivity (MEP) metric, the Route Energy Prediction Model (RouteE), and the Open Platform for Agile Trip Heuristics (OpenPATH).
- Support city data initiatives like those using OpenPATH and the Smart Columbus Operating System and promote access to vital regional data sets housed at the city and with the city's partners, encouraging integration into the Livewire data platform.
- Serve as communications broker between communities, partners, DOE, and national laboratories.
- Promote opportunities for collaboration between Smart City/Smart Community initiatives and both the EEMS and TI programs.

- Engage with NYSERDA in development of a Fellows program, comprised of early career sustainable transportation professionals enabled by mentorship and access to knowledge and other resources via the National Renewable Energy Laboratory (NREL) TIC team.
- Coordinate rural mobility research through support of DOE Funding Opportunity Announcement (FOA) projects and stakeholder engagement.

Results

Current TIC project progress, accomplishments, and results include:

- **NYSERDA:** The NREL TIC team has been engaged with NYSERDA in development of Clean Transportation prizes, an investment of over $80 million in direct funding to New York communities toward sustainable and equitable mobility. This relationship enables DOE to learn from implementation of the projects and allows NYSERDA to benefit from DOE's vast expertise and resources to maximize the benefits and success of their program. NREL is providing mentorship, training, and first-line support to the embedded staff. TIC support of the NYSERDA projects also includes:
    - Emphasis on metrics and data support: Similar to NREL's support of Smart Columbus, NREL personnel are providing prize participants a direct conduit to DOE and national laboratory tools (e.g., MEP, RouteE, OpenPATH, and equity tools), data (various aspects of the Alternative Fuels Data Center and knowledge bases), and expertise.
    - Community resource collaboration: Participants are invited to regular forums where internal (grant awardees) and external (other speakers and initiatives of import) participants share their experiences and insights. NREL facilitates a recurring forum for awardee projects, at a cadence determined through coordination with NYSERDA.
    - Emphasis on case studies: Develop NYSERDA-specific case studies and share externally and share relevant external case studies with NYSERDA program participants. Although case study topics are not prescribed, relevant topics will be identified as the program evolves.
- **TIC Scanning Tour and site visits:** The TIC team organized and conducted a scanning tour to highlight mobility technologies and applications in key locations. Tour participants included DOE technology managers and other staff who experienced evolving transit alternatives in Dallas and Arlington, Texas, including on-demand services augmenting or replacing traditional transit. See Figure II.7.1. The tour also visited Phoenix, riding the Waymo automated ride-hailing system and learning about the potential for automated technologies to meet ground mobility needs at Phoenix Sky Harbor International Airport. Elements of the tour focused on meeting mobility needs of cities with significant disadvantaged communities, considering how emerging technologies can make positive changes by improving access and affordability to mobility and improving outcomes for residents. The TIC team visited the University of Puerto Rico Mayaguëz (UPRM) as part of a National Science Foundation (NSF) Civic Innovation Challenge grant to explore the challenges of meeting mobility needs in climate-challenged Puerto Rico. The UPRM project leveraged OpenPATH data collection to inform mobility strategies. Across these sites, common themes include the need for better connection between neighborhoods with long-standing elevated unemployment and areas of concentrated employment where labor needs are often unmet.

Figure II.7.1 TIC Scanning Tour participants observing the Dallas Area Rapid Transit GoLink on-demand transit service. (Photo credit: Anna Squires, NREL)

- **Automated mobility for public transportation:** Automated mobility combines hardware and software technologies that enable vehicles to move themselves without the need for a human driver. The TIC team continues to expand and update the latest edition of *The Automated Mobility District Implementation Catalog: Insights from Ten Early-Stage Deployments* [2], which contains a collection of known automated shuttle projects and shares data and lessons learned. The latest edition not only provides summaries of new developments and lessons learned for 10 early-deployment automated mobility demonstration projects, but also assesses the various regulatory and technical issues that have emerged from initial deployments of automated shuttle and car service demonstration pilots. Continuing work is focused on automated mobility solutions for large indoor facilities, such as airport terminals, medical campuses, and similar settings.

- **Case studies of on-demand transit (ODT) alternatives for small communities:** In less-dense exurban areas where traditional transit is not feasible, latent demand for mobility options exists, particularly among population subgroups that do not own or have access to a car. Such unmet needs for mobility options affect access to employment and education opportunities, healthcare, and other critical transportation needs. The TIC team continues to explore potential solutions, observing a trend emerging for ODT alternatives. Key operational characteristics include right-sized vehicles, typically minivans or other light-duty vehicles, which may be requested via smartphone app, phone call, or hailed from the street, serving a defined area. Benefits include shorter wait times for passengers, reduced operational costs per ride, and reduced fuel use and emissions. ODT is being integrated into existing transit services, as observed in Dallas, Texas, among other locations, and instead of legacy transit operations. Arlington, Texas has never had a traditional fixed route transit system despite being a city of 400,000 residents yet is home to a thriving on-demand system that continues to grow in popularity and is focused on serving people with limited mobility options.

- **New mobility in rural America (DOE):** The NREL TIC team continues to support and coordinate communication/information exchange among the five rural mobility projects awarded through DOE's 2019 Advanced Vehicle Technologies Research FOA. Many of these projects are nearing an end, but interest in learning how their findings can inform broader interests in rural mobility solutions is growing. The TIC team has been fostering linkages within DOE and with complementary programs at DOT and FHWA and has been coordinating efforts to support mobility needs in Tribal areas, many of which exhibit mobility needs and challenges similar to other rural locations. Planning is under way for a rural mobility workshop to be held in FY2024.

- **The future of ground access to airports:** Air travel has been rebounding since the pandemic, with a growing portion of the population traveling by air. Airport facilities have been increasing in size to accommodate travelers, resulting in larger buildings that can be challenging to navigate. The TIC team has been tracking emerging automated mobility technologies relevant to ground-side access and movement within airports. This effort has resulted in multiple technical reports identifying opportunities to improve mobility options to benefit airport operations. These included assessing mobility needs for travelers, employees, goods/cargo operations, and alignment with mobility electrification. NREL has been working with numerous airports and port authorities to demonstrate or pilot relevant technologies, including next generation automated people moving vehicles, low-speed automated parking systems, and active curb management. Partnerships have emerged with the Massachusetts Department of Transportation, Dallas/Fort Worth International Airport, the Port Authority of New York and New Jersey, Cincinnati International Airport, and the University of North Carolina Charlotte.

- **Smart Columbus Program:** The TIC team continues to engage with the Smart Columbus team, including sharing information and transferring knowledge to support emerging efforts. A strong emphasis on equity and environmental justice issues is integrated within Smart Columbus 2.0, aspects of which are leading the way for similar developments in other cities in alignment with larger DOE objectives. During FY 2023, two major production facilities have been rapidly developed in the Columbus area: the $20 billion Intel chip production factory northeast of the city and a $3.5 billion LG Energy Solution/Honda electric vehicle battery production plant south of Columbus. These facilities have energized technology development funding and the infrastructure to support related activities in the metropolitan area.

- **OpenPATH as a core DOE tool:** The NREL OpenPATH data collection platform proved instrumental in collecting data for evaluation of new and novel mobility projects. OpenPATH is the go-to tool for evaluation of e-bike and other micromobility programs which have quickly become popular as a way to increase mobility accessibility and electric vehicle adoption, particularly among lower income populations. Datasets from OpenPATH enable a view into how people use e-bikes in place of larger vehicles as part of climate mitigation strategies. In recognition of this accomplishment, the Colorado Governor presented Dr. K. Shankari of the NREL TIC team an award for high-impact research. See Figure II.7.2.

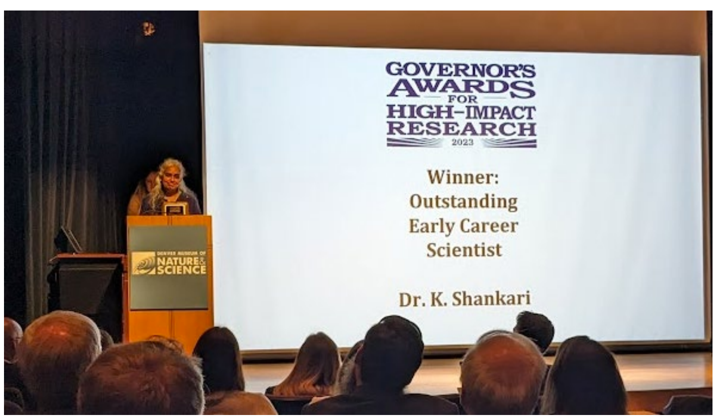

Figure II.7.2 TIC team member Dr. K. Shankari receiving Colorado Governor's award. ***(Photo credit: Andrew Duvall, NREL)***

Conclusions

During FY 2023, TIC continued to collaborate with several smart communities in their efforts, expanding into multiple areas of emerging mobility technology application. Many of the processes and methods honed during the engagement with Smart Columbus have translated into the next phase of the TIC effort, evolving to meet the varied needs and circumstances of many communities. Key examples of the interaction among these efforts are the collaboration with NYSERDA in supporting the Clean Transportation prizes through the Fellows program; the quickly growing implementation of ODT projects in multiple locations; and evaluation of how new mobility technology applications can serve communities.

The NREL TIC program is refining some objectives to identify needs of community partners and to provide options for possible solution strategies. This is meant to leverage national laboratory research outcomes to inform design and implementation of community projects. Several community partners are leading the way among their peers and may generate methods for replication elsewhere. As advised by DOE TI leadership, NREL has identified themes and priorities for FY 2024, including:

- Continued engagement with smart communities, with emphasis on mobility improvements to enhance access to economic opportunities, mitigate equity concerns, and develop metrics for evaluation.
- Cities with significant disadvantaged communities (e.g., Cleveland, Ohio; St. Louis, Missouri; Baltimore, Maryland).
- Rural mobility, workforce mobility, and access to jobs.
- Support for the NYSERDA Clean Transportation Fellows program.
- Automated public mobility, and opportunities for related demonstration and pilot-scale projects.
- Objective data analysis from Energetics and CALSTART under FOA awards, collection, and analysis of behavior data via OpenPATH, and analysis of data from Smart City advanced mobility demonstrations.

Key Publications

Young, Stanley, Andrew Duvall, Alejandro Henao, and Jeffrey Gonder. 2023. Inaugural Technologist in Communities Scanning Tour: Automated and Electrified On-Demand Mobility. Golden, CO: National Renewable Energy Laboratory. NREL/TP-5400-87448. https://www.nrel.gov/docs/fy24osti/87448.pdf.

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Young, Stanley and J. Sam Lott. 2022. The Automated Mobility District Implementation Catalog, 2nd Edition: Safe and Efficient Automated Vehicle Fleet Operations for Public Mobility. Golden, CO: National Renewable Energy Laboratory. NREL/TP-5400-83276. https://www.nrel.gov/docs/fy22osti/83276.pdf.

Lott, J. Sam, Stanley E. Young, Andrew Duvall, and Alejandro Henao. 2022. Passenger Boarding Station and Curbfront Configuration Concepts for On-Demand Services with Small Automated Vehicles: Preprint. Golden, CO: National Renewable Energy Laboratory. NREL/CP-5400-81976. https://www.nrel.gov/docs/fy22osti/81976.pdf.

References

[1] The EEMS Program uses the term mobility energy productivity (MEP) to describe the value derived from the transportation system per unit of energy consumed. Increases in mobility energy productivity result from improvements in the quality or output of the transportation system, and/or reductions in the energy used for transportation.

[2] Young, Stanley and J. Sam Lott. 2022. The Automated Mobility District Implementation Catalog, 2nd Edition: Safe and Efficient Automated Vehicle Fleet Operations for Public Mobility. Golden, CO: National Renewable Energy Laboratory. NREL/TP-5400-83276. https://www.nrel.gov/docs/fy22osti/83276.pdf.

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II.8 Fuel Economy Information Project (Oak Ridge National Laboratory)

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Start Date: October 1, 2022 End Date: September 30, 2023
Project Funding (FY23): $2,550,000 DOE share: $2,550,000 Non-DOE share: $0

Project Introduction

Oak Ridge National Laboratory (ORNL) manages the Fuel Economy Information (FEI) Program for the Department of Energy (DOE), in close collaboration with the Environmental Protection Agency (EPA). Under this program, ORNL produces and distributes the annual *Fuel Economy Guide* and manages the FuelEconomy.gov website to support the DOE's statutory responsibility to provide light-duty vehicle fuel economy information to the public (under the Energy Policy and Conservation Act of 1975 – 49 USC 32908). The FEI Program supports a continually updated electronic version of the *Guide* on the FuelEconomy.gov website, where consumers also have access to a wide array of additional information and tools. The website provides fuel economy information for over 46,800 vehicles from 1984 to present. The site also provides side-by-side comparison tools, fuel saving calculators, driving and vehicle maintenance tips, and information about advanced technologies, tax incentives, safety ratings, vehicle specifications, and more. When warranted, the FEI Program also conducts fuel economy research to support its efforts to provide timely, reliable driving tips to consumers. The project ensures that consumers have easy access to fuel economy information that is accurate, up-to-date, and useful.

Objectives

The FEI Program has several objectives:

- Help DOE fulfill its statutory responsibility to publish and distribute an annual *Fuel Economy Guide* providing information on fuel economy and estimated annual fuel costs of operating automobiles manufactured in each model year.
- Provide consumers with reliable, unbiased fuel economy information. One of the goals of the FEI Program's FuelEconomy.gov website is to be the official government source of, and leading authority on, fuel economy.
- Help improve U.S. energy security by promoting fuel economy to consumers through education and outreach.

- Help consumers make informed decisions when purchasing vehicles by (1) providing information about light-duty vehicle fuel economy and fuel costs, (2) educating consumers on the benefits of improved fuel economy, and (3) providing tools that help consumers estimate fuel use and fuel costs.
- Help DOE's Clean Cities coalitions promote alternative fuels, alternative fuel vehicles, and advanced vehicle and fuel technologies.

Approach

The FEI Program helps DOE fulfill its statutory responsibility to compile and distribute an annual *Fuel Economy Guide* by publishing the *Guide* for each new vehicle model year and maintaining an up-to-date electronic version on the FuelEconomy.gov website throughout the year. Using data collected from manufacturers by the EPA, the Program publishes an electronic version of the *Guide* in the fall and sends letters and emails to new-car dealerships, libraries, and credit unions, notifying them that the new *Guide* is available and providing a URL to its location on FuelEconomy.gov. In addition, it provides an electronic version of the current *Guide* (and previous model year editions) on the FuelEconomy.gov website. Electronic versions of the *Guide* for the current and recent model years are updated with new vehicle models and/or gas prices weekly.

The *2023 Fuel Economy Guide* currently contains information for 1,304 light-duty vehicles, including conventional gasoline and diesel vehicles, plug-in electric vehicles, flex-fuel vehicles, and fuel cell vehicles. The *Guide* provides (1) EPA city, highway, and combined fuel economy estimates, (2) annual fuel cost estimates, (3) EPA greenhouse gas (GHG) ratings, and (4) interior volumes for each vehicle. It also provides additional information, such as driving range and charge time, for plug-in electric vehicles (PEVs). The *Guide* highlights fuel economy leaders for each vehicle class and provides fuel-saving driving and maintenance tips to help consumers save money.

In addition to the annual *Fuel Economy Guide* publication, the FEI Program developed and launched the FuelEconomy.gov website in 1999. The website leverages the power of computers and the internet to reach more consumers and provide more functionality than possible within the limitations of a paper booklet. The website can be viewed on PCs, smart phones, and other mobile devices, allowing consumers to have fuel economy information at their fingertips while shopping. FuelEconomy.gov has become the FEI Program's most effective tool for reaching consumers and providing them with fuel economy information.

Unlike the print versions of the *Guide*, which contain vehicles for a single model year, the website contains information for vehicles going back to model year 1984—more than 46,800 vehicles in all. In addition to fuel economy, GHG ratings, and annual fuel costs, the website provides driving range, cost to fill the tank, EPA Smog Rating, annual petroleum consumption, National Highway Traffic Safety Administration (NHTSA) crash test results from Safercar.gov [1], and fuel economy estimates from other drivers (via the website's My MPG feature). Vehicle and fuel cost data are updated weekly, making the website much more up-to-date and complete than would be possible with a printed booklet. Furthermore, FuelEconomy.gov allows consumers to personalize fuel economy estimates, annual fuel costs, and other estimates based on their driving environment and fuel prices. Users can also compare fuel economy and other estimates on up to four vehicles side-by-side.

FuelEconomy.gov has features that address underserved populations. Most of the website information is available in Spanish, and the MotorWeek videos are shown on the V-me Spanish language channel. Tools that benefit low-income consumers include the Used Car Label tool, Fuel Savings Calculator, Trip Calculator, and Fuel-Saving Tips.

FuelEconomy.gov provides users with several search tools to help them find specific vehicles or vehicles that meet their desired criteria. Users can search by make and model, vehicle class, fuel type, engine and transmission, and other characteristics.

FuelEconomy.gov provides many other kinds of information useful to consumers:

- Lists of best and worst fuel economy vehicles.
- Answers to frequently asked questions about fuel economy.
- Links to national and local fuel prices and answers to frequently asked questions about fuel prices.
- Detailed descriptions of EPA Fuel Economy and Environment Labels.
- Discussions about the benefits of improved fuel economy, such as saving money, increasing U.S. energy security, reducing GHG emissions, and improving sustainability.
- Simple explanations of how fuel economy estimates are determined, how to select the right octane for your vehicle, and how advanced vehicle technologies save fuel.

FuelEconomy.gov's My MPG tool helps drivers calculate and track fuel economy for their vehicles. Drivers can also elect to share their real-world MPG estimates with other consumers.

FuelEconomy.gov provides several tools and calculators to help consumers make informed decisions when buying or operating a vehicle:

- *Trip Calculator.* Allows consumers to calculate the fuel costs for driving a vehicle on a specified trip. Users can enter their origin, destination, and any waypoints and select up to three candidate vehicles. The tool will map out the best route, provide directions, and estimate the fuel use and fuel cost for each selected vehicle. This is one of the most popular tools on FuelEconomy.gov.
- *Tax Incentives*. Helps car buyers determine which new and used plug-in and fuel cell electric vehicles qualify for Federal Clean Vehicle Tax Credits.
- *Fuel Savings Calculator.* Allows users to compare the fuel costs of two vehicles with different fuel economies. The FEI Program has enhanced the tool to include vehicle purchase and financing/lease costs. This is helpful when considering a vehicle that has a higher initial purchase cost but a lower fuel cost, which may save the consumer money in the long run.
- "*Can a Hybrid Save Me Money?"* Compares each hybrid to a comparably equipped conventional vehicle from the same manufacturer. This allows consumers to weigh the benefits of improved fuel economy when comparing vehicles with similar features.
- *My Plug-in Hybrid Calculator.* The fuel economy of a plug-in hybrid is highly variable and depends greatly on how it is driven and re-charged. This tool allows consumers to estimate the gasoline and electricity costs of a plug-in hybrid based on their driving habits, charging schedule, and gasoline and electricity prices.
- *Used Car Label Tool*. Generates printable fuel economy labels that sellers can affix to their vehicles or electronic images they can include in on-line ads. The used car label tool helps make official EPA fuel economy ratings part of the buying/selling process of used cars, just as it is for new ones.
- *GHG Emissions Calculator*. Estimates upstream GHG emissions rates for plug-in electric vehicles based on the user's vehicle and ZIP code.

FuelEconomy.gov makes much of its fuel economy information available to other websites, researchers, and other organizations via web services and data download. Edmunds, Chrysler.com, CHROMEDATA (used by more than 70% of U.S. vehicle manufacturers), the California Air Resources Board (CARB), Uber, and the

Florida Department of Transportation are just a few of the organizations that rely on FuelEconomy.gov for fuel economy data. DOE’s Vehicle Cost Calculator uses FuelEconomy.gov’s data, as do EPA’s Green Vehicle Guide and the joint DOE/EPA ENERGY STAR website. The FEI Program has also developed Find-a-Car and driving tips widgets that website developers can incorporate into their sites. The program is currently expanding its web services data to include Federal Clean Vehicle Tax Credit information.

Providing reliable, defensible fuel economy tips to consumers is a primary objective of the FEI Program. FuelEconomy.gov provides users with fuel-saving tips and allows consumers to personalize these tips to see how much money and fuel they can save by following them. The FEI Program compiles the fuel-saving tips based on available literature from U.S. government agencies, auto experts, and other credible sources. In recent years, the FEI Program has supported research projects aimed at quantifying factors that can increase or decrease fuel economy. Research has focused primarily on aspects of fuel economy that can be improved by driver behavior. Past research topics include (1) the effect of a dirty air filter on fuel economy and performance, (2) the effect of driving speed on fuel economy, (3) fuel economy effects of roof racks, cargo carriers, trailers, and tire pressure (4) the effects of cold and hot weather on fuel economy, (5) the effect of driving with the windows down vs. using the air conditioner, (6) the amount of fuel consumed by idling, (7) fuel economy tips for hybrids and plug-in vehicles, and (8) the effect of driving style on fuel economy. Most of the fuel-saving tips on FuelEconomy.gov are now based on research performed by the FEI Program, and these tips are often cited by news outlets, car companies, consumer sites, and other entities.

As part of its objective to help Clean Cities coalitions with their public outreach and education efforts, the FEI Program has worked in cooperation with Maryland Public Television) over the years to develop MotorWeek and MotorNews segments covering topics related to fuel economy, alternative fuels, and advanced vehicle technologies. MotorWeek airs on 92% of PBS stations nationwide, as well as on cable's MAVTV Motorsports Network and V-me Spanish-language network. After airing, these segments are posted on the Clean Cities TV YouTube channel, the Fuel Economy YouTube channel, and FuelEconomy.gov.

Ensuring that consumer access to the FuelEconomy.gov website is dependable and uninterrupted is critically important. The FuelEconomy.gov servers are located at the ORNL main campus for improved security and backup, and they are maintained by the FEI Program with help from ORNL’s computer network staff. Staff monitor systems around the clock to ensure that they are safe, functional, and compliant with all applicable cybersecurity regulations.

FuelEconomy.gov is a consumer-oriented website, and the FEI Program prides itself on being responsive to consumer comments and inquiries. Consumers and media contacting FuelEconomy.gov can expect a response within a few business days (or sooner).

Results

In FY 2023, the FEI Program continued to help DOE meet its statutory requirement to produce an annual *Fuel Economy Guide* for light-duty vehicles. Model year 2023 was the sixth year for a primarily electronic-only Guide. In previous years, close to 200,000 guides were printed and mailed to new car dealers, public libraries, and credit unions. The FEI Program now mails letters inviting these parties to register for routine email communications about the newest *Guide* and encouraging the use of the website to view the more up-to-date *Guide* or to use Find and Compare Cars. The electronic version of the 2023 Guide, which the FEI Program updates weekly, is available on-line at FuelEconomy.gov. In addition, the FEI Program has made a preliminary, data-only version of the 2024 *Guide* available to the public on FuelEconomy.gov, as of the third quarter of FY 2023. This preliminary version contains data for model year 2024 vehicles already released by manufacturers. The 2024 *Guide* will be finalized and distributed in the first quarter of FY 2024.

Since its launch in 1999, FuelEconomy.gov has hosted more than 575 million user sessions. Traffic on the website has increased significantly since 1999, peaking at more than 58 million visitors per year in 2013 when

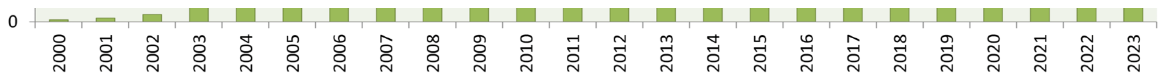

Figure II.8.1). In FY 2023, FuelEconomy.gov hosted nearly 29.5 million user sessions, more than 450 million page views, and more than 80,000 daily visits on average.

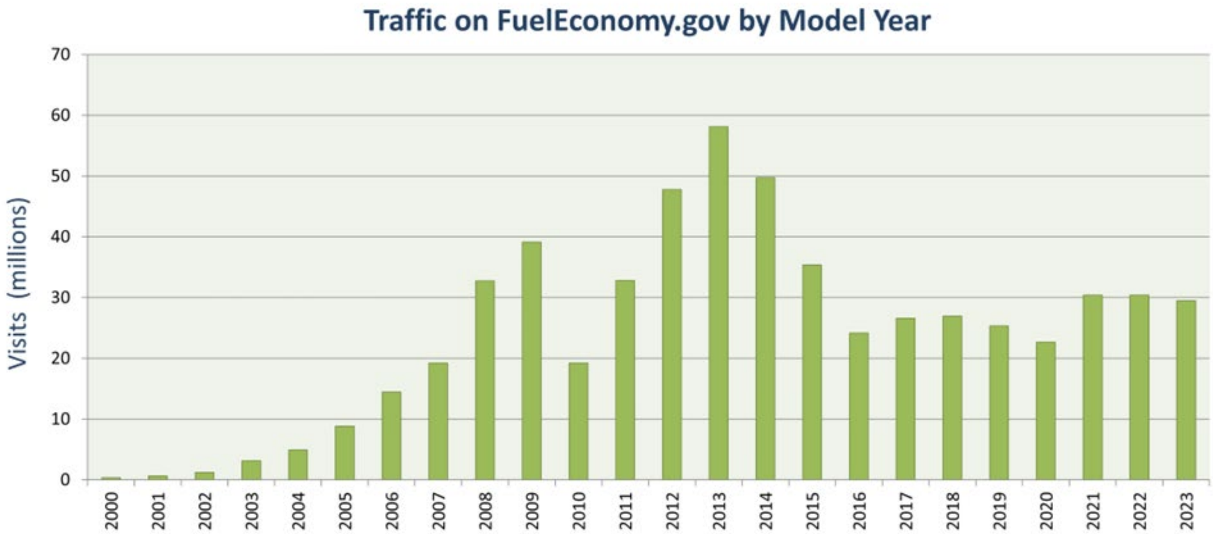

Figure II.8.1 Traffic on FuelEconomy.gov grew steadily after its initial launch in 1999, peaking in 2013 when fuel prices were high.

FuelEconomy.gov's My MPG tool continues to be popular with consumers. More than 35,700 drivers have shared fuel economy estimates for more than 51,300 vehicles. This fuel economy data has become a valuable resource for both the car-buying public and researchers looking to understand the relationship between on-road fuel economy and EPA estimates. In fact, My MPG data has been used to evaluate EPA test methods and identify potential problems with fuel economy estimates provided to EPA by manufacturers.

FuelEconomy.gov became the official online source for Clean Vehicle Tax Credit information in MY 2023. At the request of the DOE Office of Energy Efficiency and Renewable Energy (EERE) and the Internal Revenue Service (IRS), the FEI project team developed and deployed consumer-friendly data tools on FuelEconomy.gov to help the public understand and navigate the new tax credits for new and pre-owned plug-in and fuel cell electric vehicles. IRS provides the FEI Program with the tax incentive data which is updated periodically.

In addition to weekly fuel economy data updates, ORNL updated/improved other parts of the website: GHG Emissions Calculator eGRID data, Power Profiler data, Federal tax incentive data, NHTSA vehicle safety data, EPA GHG and smog ratings data, and other routine content updates.

MotorWeek segments completed in FY 2023 include two segments related to electric vehicles ("Utility Supplier Powers up for Electric Vehicles in New York" and "Making EV Ridesharing Accessible"), one on hydrogen ("Hydrogen Helps First Responders Toward a Zero-Emission Future"), one on renewable natural gas ("Wastewater Powers Renewable Natural Gas Trucks in Colorado"), and one on the Clean Cities Program ("Clean Cities 30th Anniversary Celebration"). [2]

The FEI Program began a study investigating the effect of speed on battery electric vehicle (BEV) range and energy consumption. The team used a modeling approach pioneered by researchers at Ford Motor Company to

analyze data from two publicly accessible EPA databases covering all model year 2020–2024 BEVs. Results showed that the range on the Fuel Economy and Environment window sticker is a reasonable approximation of the range when the vehicle is driven at a steady speed of 65 mph. Range decreases by a median value of about 15% for every 10 mph increase in speed above 65 mph. The results of the study have been submitted for publication at the 2024 SAE WCX Meeting. The underlying data from the speed and range study are also being used to facilitate a study of the impact of replacement tires on BEV range.
Research by the FEI Program into driving and maintenance factors that affect fuel economy provides useful, actionable information for drivers wishing to reduce their energy use. The fuel-saving tips pages are a popular destination on FuelEconomy.gov, and the tips are frequently featured by the news media. In addition, automotive researchers frequently use information on FuelEconomy.gov and cite the website, reports, and papers produced under the auspices of this program. To date, reports and papers from this program have been cited over 2,257 times in the technical literature. Finally, the FEI Program responded to 692 email inquiries submitted by media and users through FuelEconomy.gov in FY 2023.

In addition to its popularity with consumers, FuelEconomy.gov is a trusted resource for television, print, and online media. Over the years, information on FuelEconomy.gov has been featured in articles by national news outlets like CBS News, CNN, Fox News, NBC News, Reuters, Time Magazine, USA Today, The Washington Post, and Yahoo! News; financial news outlets like Bloomberg.com, Forbes.com, Fortune.com, and MarketWatch; automotive news such as Autoblog, Automotive News, Car and Driver, Cars.com, and MotorTrend; local newspapers and television news; and college newspapers. It has also been cited by Ford Motor Company Newsroom, Toyota USA, and Volkswagen of America. So, in addition to reaching consumers directly, FuelEconomy.gov also reaches them through print and online materials from other sources.

Conclusions

In FY 2023, the FEI Program continued to meet its objectives.

FuelEconomy.gov is an effective information resource for consumers and an effective outreach tool for promoting fuel economy and alternative fuels. Its popularity with consumers and its reputation with media make it a powerful platform for educating the public about fuel economy.

FEI Program research on factors affecting vehicle fuel economy has played an important role in assuring that FuelEconomy.gov's fuel-saving tips are accurate and up to date. In fact, these tips, which are used widely by many media sources, are one of the reasons FuelEconomy.gov is considered a trusted and authoritative source of fuel economy information. Website content has also been used in research publications, which further speaks to the website's reputation for providing reliable information. This allows FuelEconomy.gov's reach to far exceed just those consumers that visit the website.

The FEI Program plays an important role in educating the public about fuel economy and providing information to consumers. Through the *Fuel Economy Guide*, FuelEconomy.gov, and its education and outreach efforts, the FEI Program continues to help increase U.S. energy security by promoting the efficient use of energy resources.

Key Publications

U.S. Department of Energy and U.S. Environmental Protection Agency. 2023. *Model Year 2023 Fuel Economy Guide*. https://www.fueleconomy.gov/feg/pdfs/guides/FEG2023.pdf.

Huff, S., S. Davis, R. Boundy, and R. Gibson. 2023. "Auto Stop-Start Fuel Consumption Benefits." SAE Technical Paper 2023-01-0346. https://doi.org/10.4271/2023-01-0346.

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