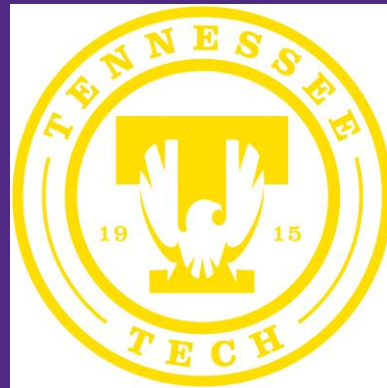


# Developing an Electrified Vehicle Demonstration Testbed in the Upper Cumberland Region of Tennessee, an Economy Distressed Rural Region



Project ID: ti124

Principal Investigator & Presenter: Professor Pinggen Chen

Tennessee Technological University

6/24/2021

# Overview

## Timeline

- ❖ Start: October 1<sup>st</sup>, 2019
- ❖ End: December 31<sup>st</sup>, 2022
- ❖ 50% Complete

## Partners

- ❖ East Tennessee Clean Fuels Coalition
- ❖ Nissan North America
- ❖ Phoenix Motorcars
- ❖ University of Texas at Austin
- ❖ Seven States Power Corporation
- ❖ ChargePoint
- ❖ Upper Cumberland Human Resource Agency (UCHRA)
- ❖ Oak Ridge National Laboratory
- ❖ Lyft

## Budget

- ❖ Total project funding: \$1,559,686
  - ❖ DOE Share: \$779,823
  - ❖ Cost Share: \$779,863
- ❖ Total project expended: \$ 714,368
  - ❖ DOE share: \$352,320
  - ❖ Cost share: \$362,048

## Barriers addressed

- ❖ Lack of EV exposure and experience in rural communities
- ❖ Lack of EV infrastructure in rural areas
- ❖ Lack of information for EV adoption in rural areas

# Project Objectives

## Objectives

- ❖ To help rural communities make informed decisions in EV adoption
- ❖ To support knowledge gaining, transfer, outreach and education on EVs for rural applications, and
- ❖ To compliment DOE VTO's existing EV data set with EV operation and use data in rural applications

## VTO TI Goals

- ❖ National Security (fuel diversity, alternative fuels)
- ❖ Economy Growth (business opportunities related to advanced vehicle technologies)
- ❖ Affordability for business and consumers (cost savings from increased efficiency, alternative fuels)
- ❖ Reliability/resiliency (infrastructure reliability, diverse/resilient fueling, and transportation options)

## Impacts

- ❖ Accelerate adoption of EVs in rural communities
- ❖ Reduce rural transportation cost and emissions
- ❖ Increase availability of EV charging infrastructure

# Project Approach

## Overall approach

- ❖ To develop a rural EV testbed (including 5 PEVs and EV infrastructure) to demonstrate and evaluate the applications of EVs in a rural Upper Cumberland (UC) region in TN

## Main tasks

- ❖ Establish Public Charging Station Network in UC Region
- ❖ Delivery and Instrumentation of PEVs
- ❖ EV Demonstration
- ❖ Data Collection
- ❖ Data Analysis
- ❖ Information Sharing & Outreach
- ❖ Education

# Milestones (1/2)

Project Period 1 Milestones (FY 2020)	Type	Progress
Data Collection and Data Analysis	Technical	Achieved
Information Sharing & Outreach	Technical	Achieved
Education	Technical	Achieved
EV Demonstration ✓ Establish Public Charging Station Network in UC Region ✓ Delivery and Instrumentation of PEVs ✓ Demonstrating at least 3 PEVs	Go/No Go	Achieved

Project Period 2 Milestones (FY 2021)	Type	Progress
Data Collection and Data Analysis	Technical	In progress
Information Sharing & Outreach	Technical	In progress
Education	Technical	In progress
EV Demonstration ✓ Successful Installation of All Planned Charging Stations ✓ Delivery and Instrumentation of PEVs ✓ All data are collected ✓ All outreach activities completed	Go/No Go	In progress

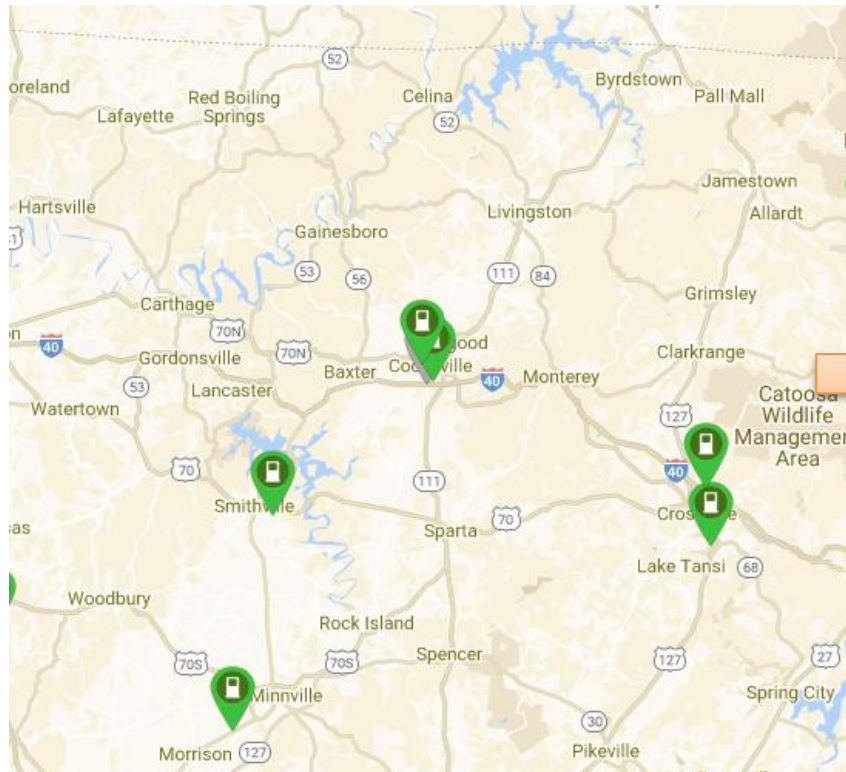
# Milestones (2/2)

<b>Project Period 3 Milestones (FY 2022)</b>	<b>Type</b>	<b>Progress</b>
Data Collection	Technical	TBA
Data Analysis	Technical	TBA
Education	Technical	TBA
Information Sharing & Outreach	Technical	TBA

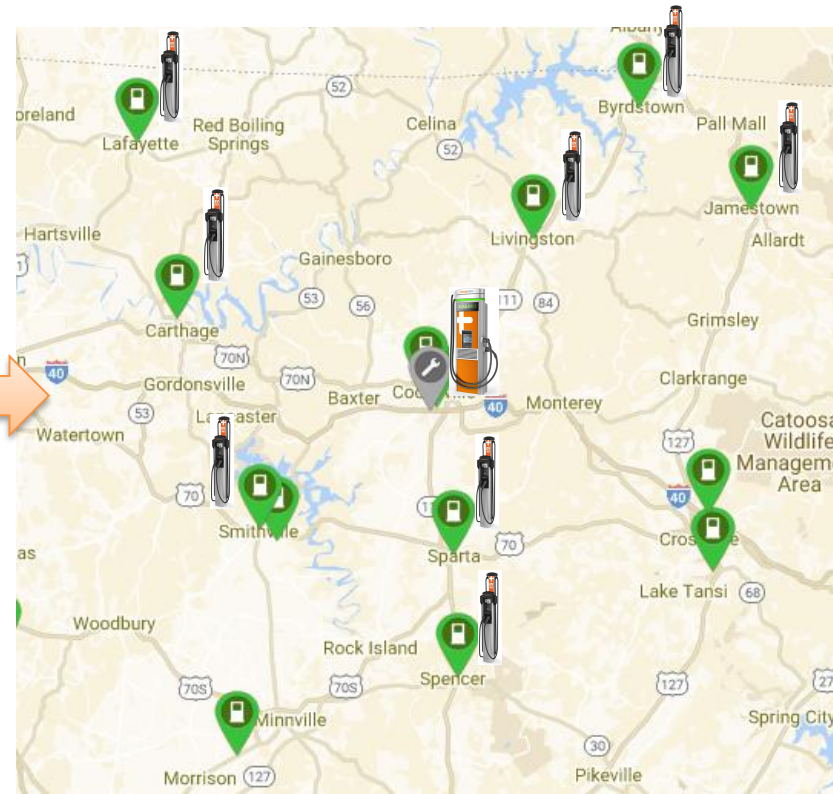
# Project Accomplishments and Progress (1/10)

## EV Charging Infrastructure Development

- ❖ Sites and hosts for 8 dual-port level-2 and 1 DC fast charging (DCFC) stations identified
- ❖ All charging stations acquired and installed in 9 cities in project site
- ❖ Recorded 187 charging sessions, 66 distinct EV users, 2,322 kWh energy consumption



Before



After



Dual-port level-2 charger



62.5-kW DCFC station

# Project Accomplishments and Progress (2/10)

## PEV Deployment and Instrumentation

- ❖ 3 Nissan Leaf EVs (150-mile and 229-mile)
- ❖ 1 plug-in hybrid F250 pickup truck
- ❖ Data acquisition systems (HEM OBD data logger + XL plug-in app.)

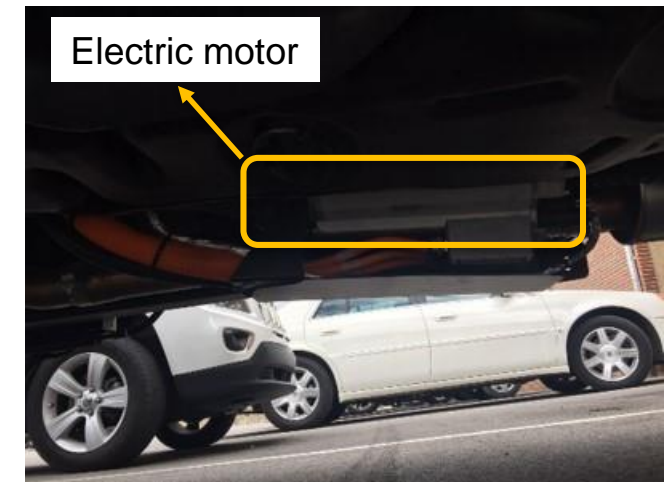
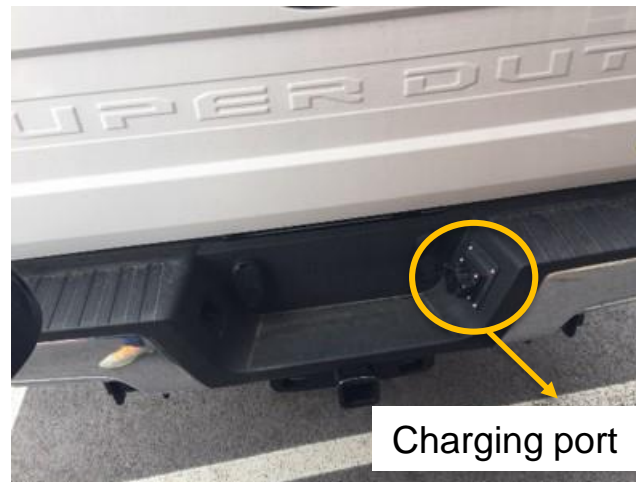
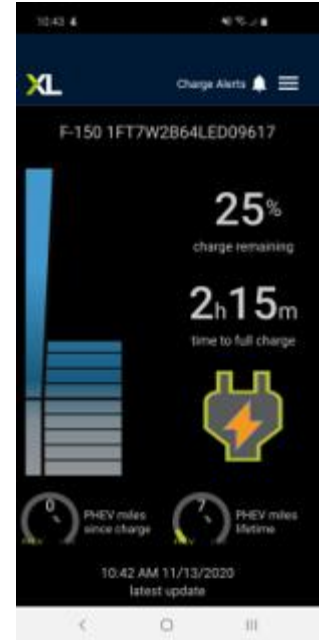




# Project Accomplishments and Progress (3/10)

## Plug-in Hybrid Pickup Truck Information

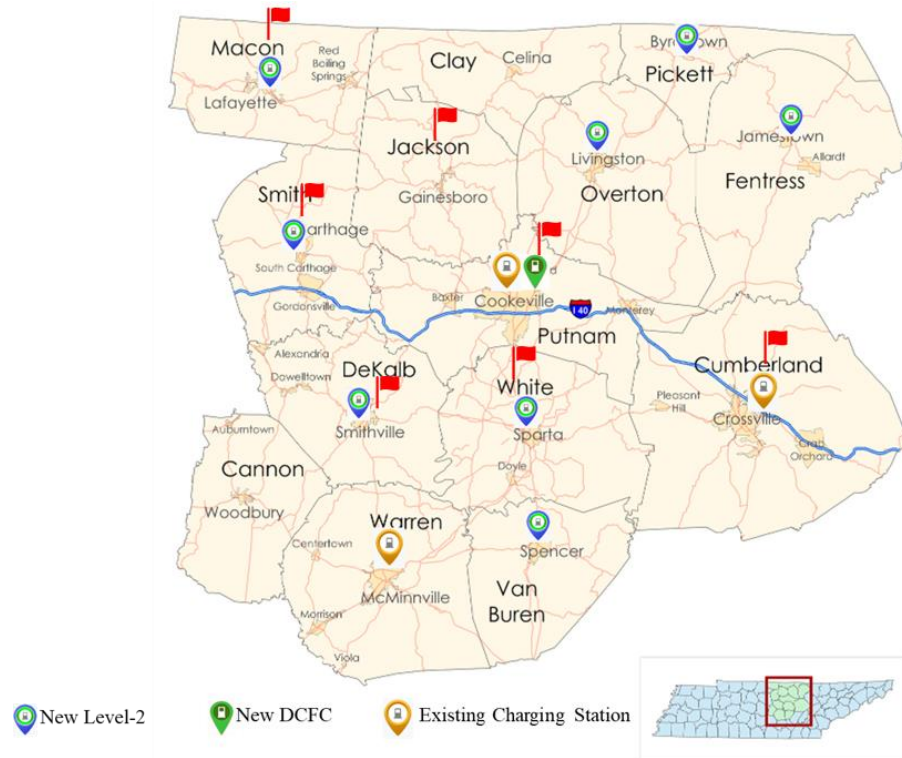
- ❖ Motor is inline with the driveshaft of the original powertrain
- ❖ Can be charged by level-1 or level-2
- ❖ Control strategy: hybrid system mostly assists during acceleration events.
  - ❖ Charge depletion mode: actual SOC decrease until around 21%;
  - ❖ Charge sustaining mode: actual SOC maintained around 21%;
- ❖ Data collection: full access to conventional powertrain data + SOC data from XL plug-in app (→)
- ❖ SOC display and data acquisition system will be added to vehicle soon



# Project Accomplishments and Progress (4/10)

## PEV Demonstration and Data Collection

- ❖ Established unique EV test-drive program (participants allowed to test drive for 2 weeks)
- ❖ Contacted by 249 resident in UC region, 54 full applications,
- ❖ 41 test-drives, 24,049 EV miles in UC region
- ❖ Test drive reached 7 of 14 counties in UC region



**TENNESSEE TECH EV DEMO PROJECT**

## SEEKING VOLUNTEERS FOR EV TEST DRIVE

**TWO WEEKS USAGE FOR FREE**

### VOLUNTEER CRITERIA

- at least 21 years old
- valid U.S. driver's license ( $\geq 1$  year)
- clean driving record
- proof of vehicle insurance
- no criminal or poor financial history
- resident in Upper Cumberland, TN

If interested, please fill out the **start form**.  
[https://tntech.co1.qualtrics.com/jfe/form/SV\\_cBGNFoCwqyUIWdD](https://tntech.co1.qualtrics.com/jfe/form/SV_cBGNFoCwqyUIWdD)

**More Info.** **Contact Information** **Start Form**

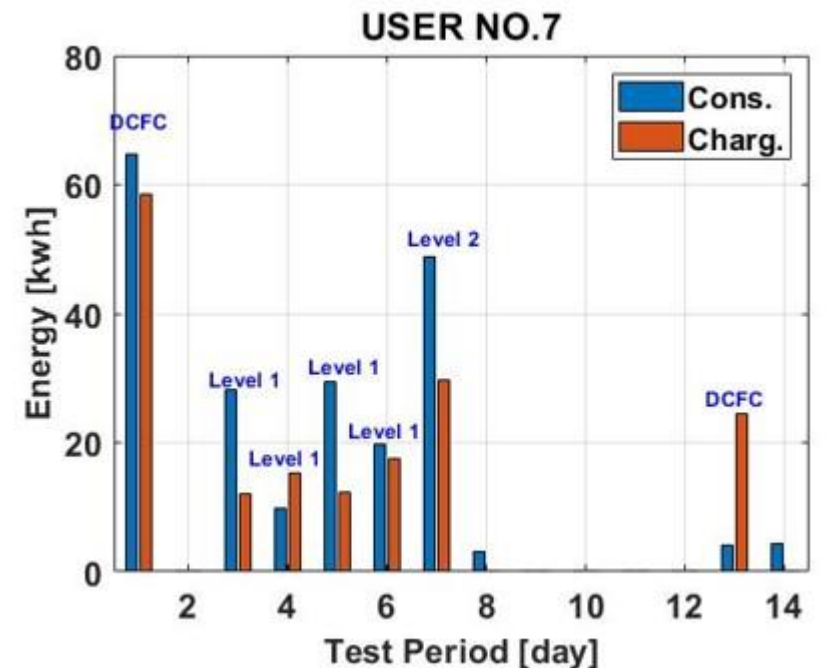
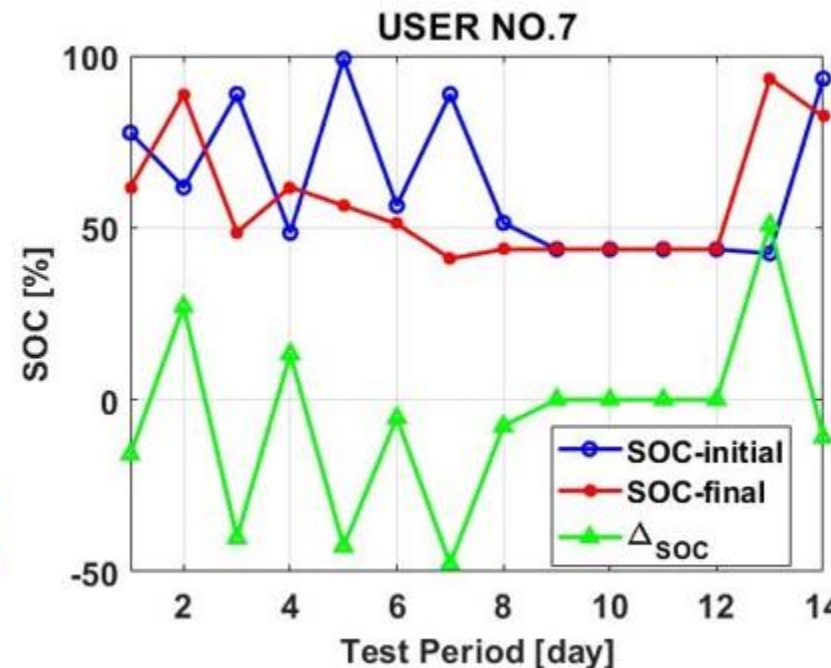
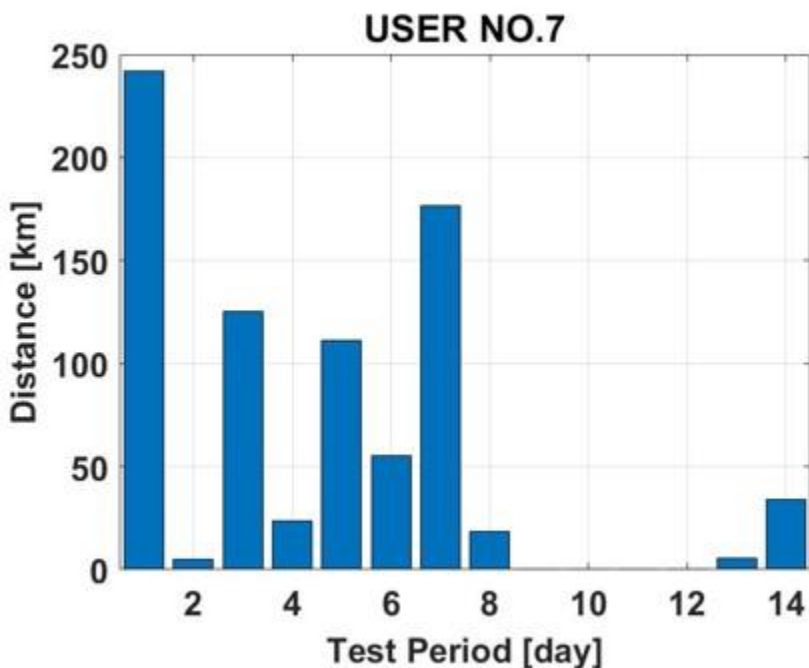
Prof. Pingan Chen,  
Address: Brown Hall 115, 115 W. 10th St.,  
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Phone: 931-372-3310

SCAN ME SCAN ME

# Project Accomplishments and Progress (5/10)

## PEV Data Collection

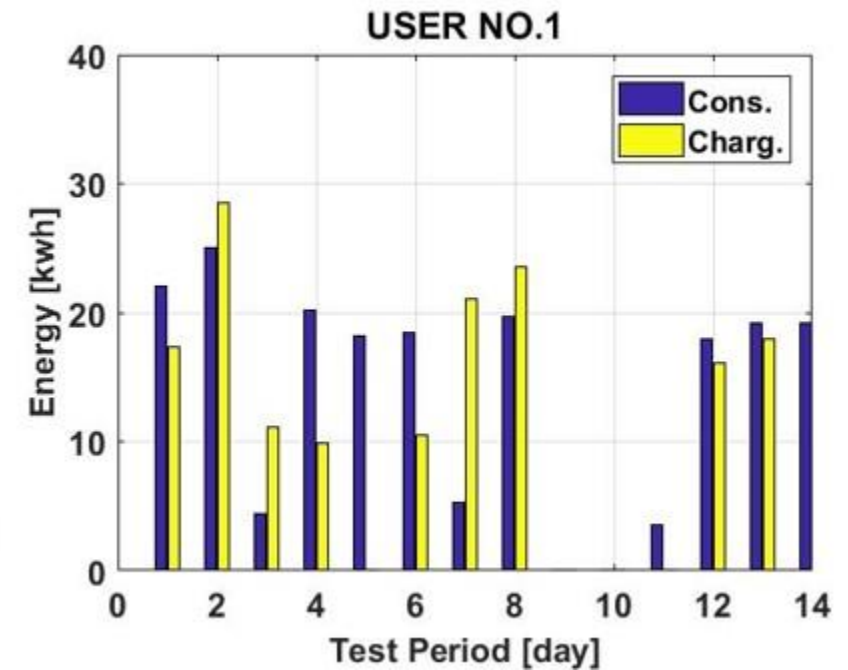
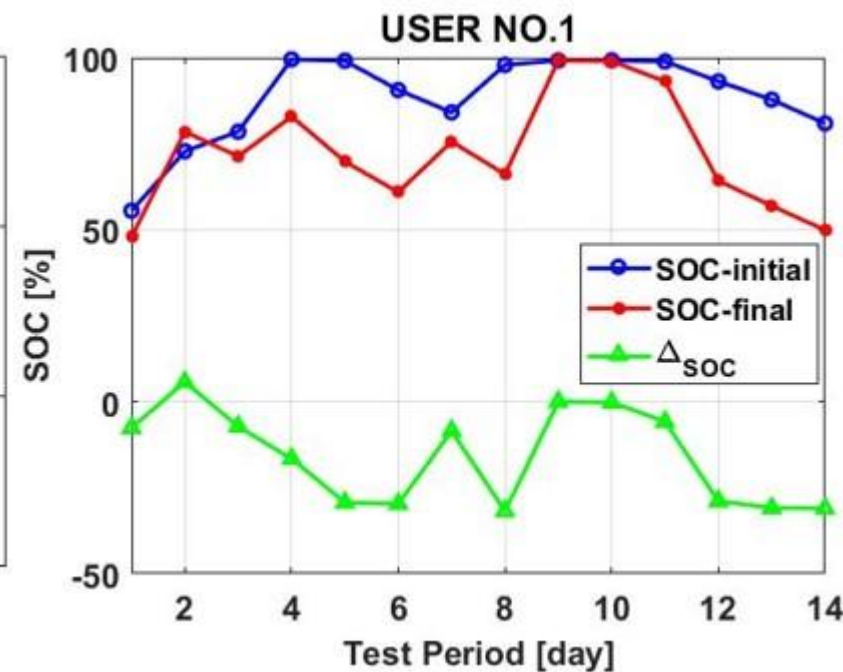
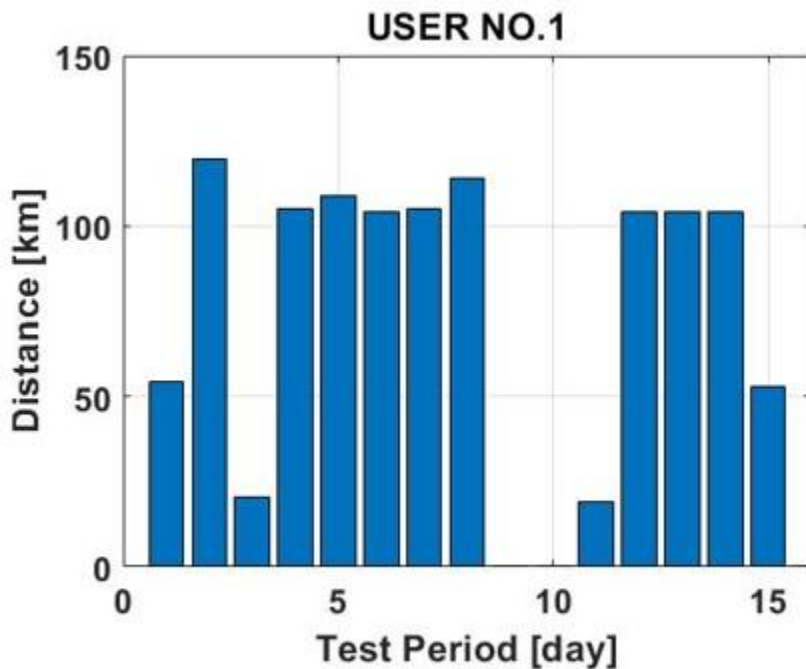
- ❖ EV operation data (second-by-second vehicle speed, SOC, motor speed, and others)
- ❖ Charging behavior data (type, initial and final SOC, starting and finishing charging time)
- ❖ Plug-in hybrid pickup truck data (comprehensive engine data, vehicle speed, and starting and finishing SOC data for each micro-trips)
- ❖ Pre-demonstration survey, post-demonstration survey and interview data



# Project Accomplishments and Progress (6/10)

## EV Data Analysis

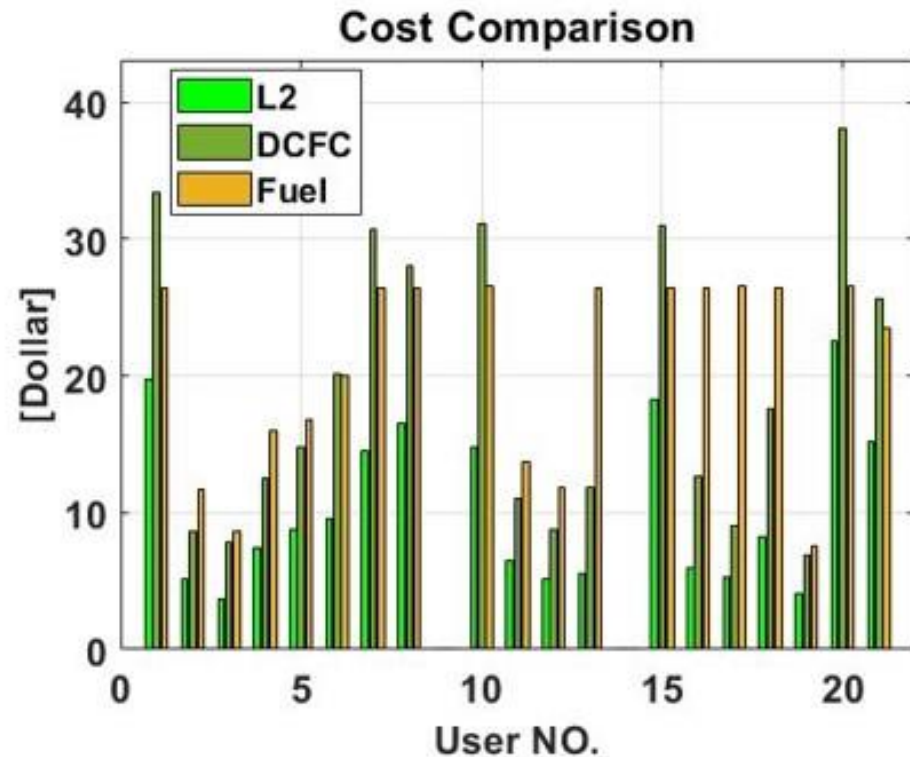
- ❖ Key question 1: can EV meet the needs in rural Upper Cumberland region?
  - ❖ Short daily commute can be met with 150-mile EV
  - ❖ Long daily commute can be met with 226-mile EV and access to level-2 or DCFC charging stations
  - ❖ Case study: rural EV user with long daily commute (↓)



# Project Accomplishments and Progress (7/10)

## EV Data Analysis

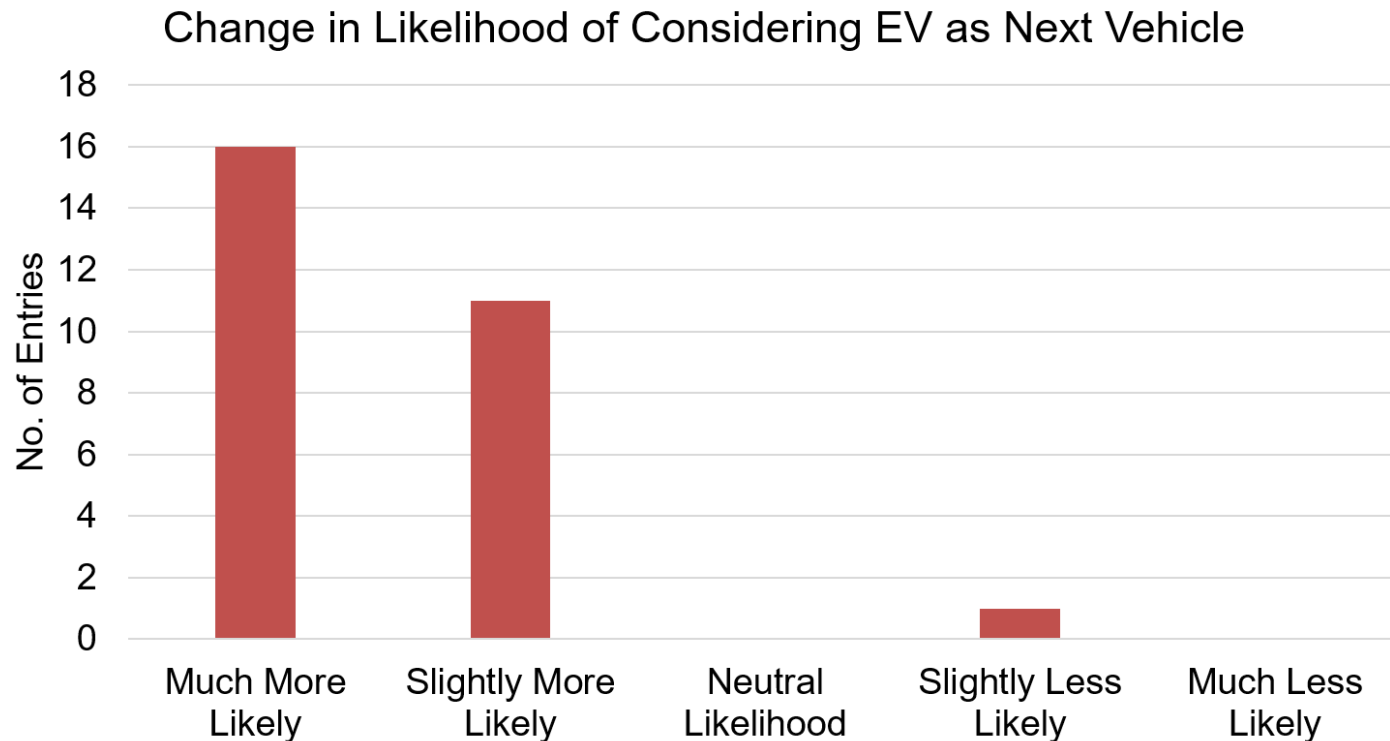
- ❖ Key question 2: what are the fuel saving benefits over conventional vehicles?
  - ❖ Level-2 charging can achieve significant cost saving for EV owners/users
  - ❖ DCFC may result in higher pump-to-wheel cost (\$) due to high charging price



# Project Accomplishments and Progress (8/10)

## Survey Data Analysis

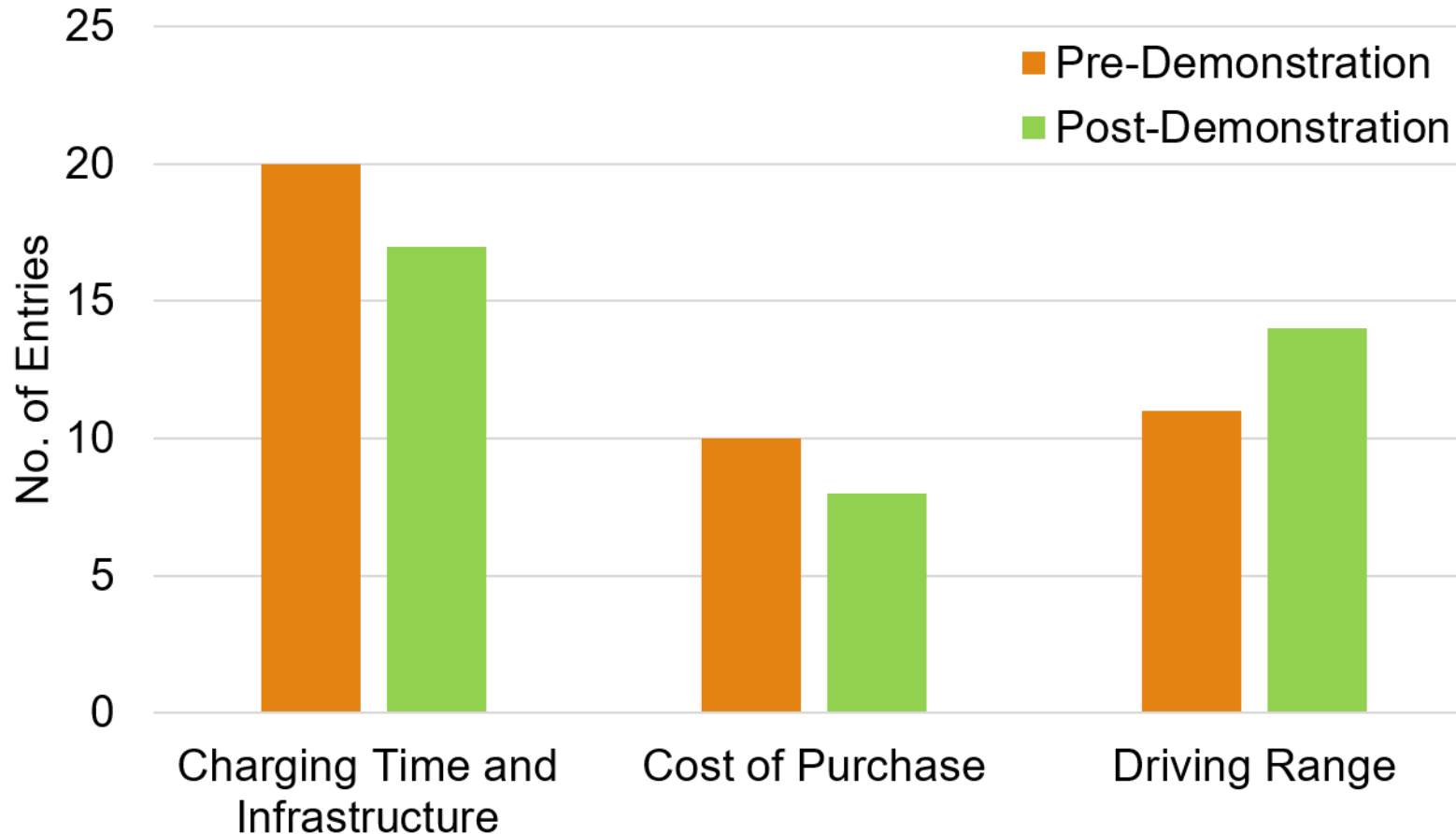
- ❖ Key question 3: How EV test-drive experience will impact EV adoption in rural areas?
  - ❖ Majority of participants in test-drive program are more likely to adopt EV as next vehicle
  - ❖ Some participants are already in the market



# Project Accomplishments and Progress (9/10)

## Survey Data Analysis

- ❖ Key question 4: What are main barriers for EV adoption in rural areas?
  - ❖ Limited charging infrastructure and EV driving range are top 2 concerns in rural applications
  - ❖ More data to be collected to analyze top barriers



# Project Accomplishments and Progress (10/10)

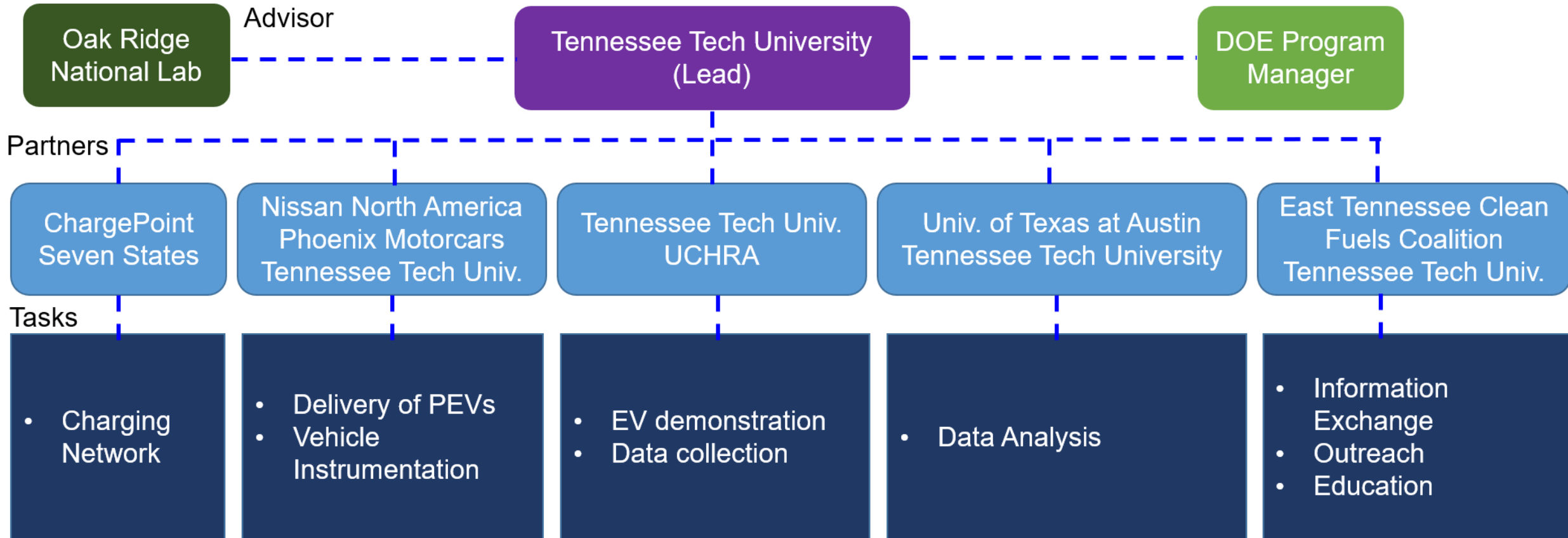
## Information Exchange, Outreach and Education

- ❖ 1 DCFC Unveiling Event
- ❖ Two 2020 National Drive Electric Week (NDEW) events
- ❖ 1 2021 Drive Electric Earth Day (DEED) event
- ❖ 2 webinar series to prepare rural communities for EV adoption(→)
- ❖ Engaged high school & college students for EV education
- ❖ Engaged EV stakeholders (dealers, policy makers, EV manufacturers, chambers of commerce, etc)





# Collaboration and Coordination



# Overall Impacts

## Accomplishments to date

- ❖ Developed a comprehensive EV charging station network to support EV operation in rural UC region
- ❖ Demonstrated, and exposed 4 PEVs (3 EVs + 1 PHEV pickup truck) to many residents in rural UC region
- ❖ Conducted in-depth data analysis to address fundamental questions relevant to rural EV adoption
- ❖ Conducted more than 6 major outreach activities to educate rural communities on EV benefits
- ❖ Engaged various stakeholders to build complete EV ecosystem in rural UC region

## Upcoming/In Progress (in FY 2021 and FY 2022)

- ❖ Continue EV demonstration, data collection & analysis, information exchange, outreach & education
- ❖ To acquire and demonstrate an electric bus to UCHRA (transit agency) and perform data analysis

## Sustainability

- ❖ Various EV stakeholders have been engaged in this project to make EV ecosystem sustainable
- ❖ New findings, observations, best practice and lessons learned, will be disseminated in various forms to help significantly accelerate EV adoptions in other rural areas across United States

# Summary

## Goals

- ❖ To help rural communities make informed decision in EV adoption
- ❖ Gain knowledge of EV operation in rural areas and promote EV awareness and readiness
- ❖ Compliment DOE VTO's existing EV data set

## Approach

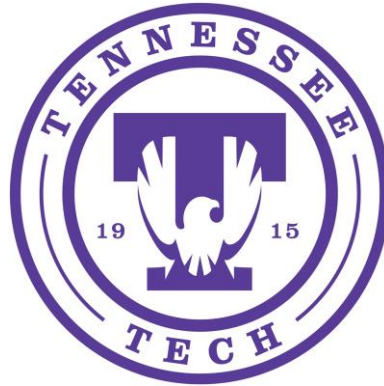
- ❖ EV charging infrastructure development
- ❖ EV demonstration in private and public fleet
- ❖ Data collection and data analysis
- ❖ Information exchange, outreach and education, ecosystem development

## Achievements

- ❖ Developed a first-of-the-kind rural EV testbed in UC region including a comprehensive charging station network and a small fleet of PEVs with open access
- ❖ Demonstrated PEVs to diverse rural communities through a unique test-drive program and various outreach activities to help understand EV operation and benefits
- ❖ Collected and analyzed a large set of EV & charging station data in rural settings to address key questions associated with EV adoption in rural areas

# Thank You!

## Questions?



Project ID: ti124  
Principal Investigator and Presenter: Prof. Pinggen Chen  
Tennessee Technological University  
6/24/2021