



# Electric Vehicle Transportation Center

## Semi-annual Program Progress Performance Report for University Transportation Center

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**Semi-annual Program Progress Performance Report #10**  
**Electric Vehicle Transportation Center**  
**Submitted by:**  
**University of Central Florida**

## **I. Accomplishments**

### *What are the major goals and objectives of the program?*

The Electric Vehicle Transportation Center (EVTC) supports the U.S. Department of Transportation's strategic goal of planning for near-term integration of alternative fuel vehicles as a means to build a sustainable transportation system. The project objectives are to evaluate technologies, standards, planning and policies to ensure seamless integration of electric vehicles (EVs) into a complex transportation network and electricity grid. The EVTC bridges the gap between deployment of electric vehicles and the traditional transportation system.

### *What was accomplished under these goals?*

**Summary:** The major activity of the past reporting period has been the completion of the 2 remaining final project research reports. During the period, these two projects (numbers 2 and 21) were completed and the final project reports forwarded to DOT and the required associated organizations.

## **Research and Development Accomplishments**

The EVTC R&D agenda has completed work on 22 projects. A summary of results for each project are presented in the following sections.

### **1. Implications of Electric Vehicle Penetration on Federal and State Highway Revenues**

**Objective:** *Research the impact that increased use of electric vehicles will have on federal and state highway revenue sources. This work will identify existing laws and policies that govern highway, gas, and vehicle taxes and fees imposed on vehicles and summarize current trends and policy recommendations that may influence both the growth of the electric vehicle market and impact highway revenues.*

**Accomplishments:** This project is completed and the final project report has been forwarded to DOT and the required DOT associated organizations. The project 1 final report is posted on the EVTC web site at: <http://fsec.ucf.edu/en/publications/pdf/fsec-cr-2052-17.pdf>

### **2. Identify and Analyze Policies that Impact the Acceleration of Electric Vehicle Adoption**

**Objective:** *Examine state and national regulatory policies to determine their impact on the long term adoption of electric vehicles. The work will include discussion with Florida utility companies and with existing electric vehicle stakeholder groups. New policies and or regulations will be developed and suggested to the appropriate authorities. This project will also include Hawaii and Alabama.*

**Accomplishments:** This project is completed and the final project report has been forwarded to DOT and the required DOT associated organizations. The project 2 final report is posted on the EVTC web site at: <http://publications.energyresearch.ucf.edu/wp-content/uploads/2018/09/FSEC-CR-2087-18.pdf>

### **3. Electric Vehicle Charging Technologies Analysis and Standards**

**Objective:** *Assess current and emerging technologies, codes and standards associated with Electric Vehicle Service Equipment (EVSE), Electric Vehicles (EVs) and the related infrastructure. The work will recommend policies and best practices to advance both vehicle and EVSE deployment. Collect and analyze 50kW DC fast charger usage data to evaluate electrical power impact.*

**Accomplishments:** This project is completed and the final project report has been forwarded to DOT and the required DOT associated organizations. The project 3 final report is posted on the EVTC web site at: <http://fsec.ucf.edu/en/publications/pdf/FSEC-CR-2057-17.pdf>.

#### **4. Transportation Planning for Electric Vehicle and Associated Infrastructure**

***Objective:** Identify and examine transportation infrastructure planning models and related policy issues associated with the deployment of Electric Vehicles (EVs). Recommendations for planning and policy actions to accommodate EVs and EVSE infrastructure will be provided and an assessment of the how EVSE infrastructure planning will enhance EV acceptance will be produced. Infrastructure deployment feasibility models will also be developed.*

**Accomplishments:** This project is completed and the final project report has been forwarded to DOT and the required DOT associated organizations. The project 4 final report is posted on the EVTC web site at: <http://fsec.ucf.edu/en/publications/pdf/FSEC-CR-2068-17.pdf>

#### **5. Prediction of Electric Vehicle Penetration**

***Objective:** Identify past and present trends in electric vehicle sales to establish a baseline of electric vehicle penetration and to predict electric vehicle sales and sales characteristics within the U.S. Compare EV sales by states and evaluate the types of barriers to EV usage and the actions or incentives to overcome the barriers.*

**Accomplishments:** This project is completed and the final project report has been forwarded to DOT and the required DOT associated organizations. The project 5 final report is posted on the EVTC web site at: <http://fsec.ucf.edu/en/publications/pdf/FSEC-CR-2069-17.pdf>.

#### **6. Electric Vehicle Life Cycle Cost Analysis**

***Objective:** Compare total life cycle costs of electric vehicles, plug-in hybrid electric vehicles, hybrid electric vehicles, and compare with internal combustion engine vehicles. The analysis will consider both capital and operating costs in order to present an accurate assessment of lifetime ownership costs. The analysis will include vehicle charging scenarios of photovoltaic (solar electric) powered charging and workplace charging.*

**Accomplishments:** This project is completed and the final project report has been forwarded to DOT and the required DOT associated organizations. The project 6 final report is posted on the EVTC web site at: <http://fsec.ucf.edu/en/publications/pdf/fsec-cr-2053-17.pdf>.

#### **7. Assess Existing Software and Databases**

***Objective:** Evaluate the feasibility of using the existing software and data bases as platforms for analyzing the attributes of electric vehicles within present and future transportation infrastructure projects and models.*

**Accomplishments:** This project is completed and the final project report has been forwarded to DOT and the required DOT associated organizations. The project 7 final report is posted on the EVTC web site at: <http://fsec.ucf.edu/en/publications/pdf/fsec-cr-2054-17.pdf>.

#### **8. Battery Technologies for Mass Deployment of Electric Vehicles**

***Objective:** Assess current and emerging battery technologies and the requirements for their commercialization; align with DOE targets for future EV batteries. Focus will be placed on battery technologies, charging cycles, lifetimes, safety, codes and standards, and economics.*

**Accomplishments:** This project is completed and the final project report has been forwarded to DOT and the required DOT associated organizations. The project 8 final report is posted on the EVTC web site at: <http://www.fsec.ucf.edu/en/publications/pdf/FSEC-CR-2079-18.pdf>.

## 9. Electric Vehicle Battery Durability and Reliability under Electric Utility Grid Operations

**Objective:** *Determine the impact of electric vehicle use on battery life including charging cycles and vehicle-to-grid (V2G) applications. The work will identify conditions that improve battery performance and durability. Focus will be placed on providing battery data for system engineering, grid modeling and cost-benefit analysis.*

**Accomplishments:** This project is completed and the final project report has been forwarded to DOT and the required DOT associated organizations. The project 9 final report is posted on the EVTC web site at: <http://fsec.ucf.edu/en/publications/pdf/FSEC-CR-2064-17.pdf>.

## 10. Fuel Cell Vehicle Technologies, Infrastructure and Requirements

**Objective:** *Investigate state-of-the-art fuel cell vehicle technologies, and current infrastructure developments. Conduct comparative study of fuel cell vehicles and battery electric vehicles in terms of technical and economic viability.*

**Accomplishments:** This project is completed and the final project report has been forwarded to DOT and the required DOT associated organizations. The project 10 final report is posted on the EVTC web site at: <http://fsec.ucf.edu/en/publications/pdf/FSEC-CR-2059-17.pdf>.

## 11. Electric Vehicle Grid Experiments and Analysis

**Objective:** *Provide data from experimental vehicle-to-grid laboratory simulations. The results of the experimental data will be used in the EVTC techno-economic simulation project.*

**Accomplishments:** This project is completed and the final project report has been forwarded to DOT and the required DOT associated organizations. The project 11 final report is posted on the EVTC web site at: <http://www.fsec.ucf.edu/en/publications/pdf/FSEC-CR-2076-18.pdf>.

## 12. Electric Vehicle Interaction at the Electrical Circuit Level

**Objective:** *Investigate the effect of electric vehicle adoption on the circuit level utility distribution grid for both residential and commercial applications by determining the impact of electric vehicle charging and discharging to the grid.*

**Accomplishments:** This project is completed and the final project report has been forwarded to DOT and the required DOT associated organizations. The project 12 final report is posted on the EVTC web site at: <http://www.fsec.ucf.edu/en/publications/pdf/FSEC-CR-2077-18.pdf>.

## 13. Optimal Charging Scheduler for Electric Vehicles on the Florida Turnpike

**Objective:** *Develop the methodology for analyzing the roadway traffic patterns and expected penetration and timing of electric vehicles (EVs) on the Florida Turnpike. The work will determine the requirements for electric vehicle supply equipment at turnpike plazas, the options for equipment siting and the economics.*

**Accomplishments:** This project is completed and the final project report has been forwarded to DOT and the required DOT associated organizations. The project 13 final report is posted on the EVTC web site at: <http://fsec.ucf.edu/en/publications/pdf/FSEC-CR-2070-17.pdf>.

#### 14. Electric Vehicle Bus Systems

**Objective:** Investigate the implementation strategy and the operation of an electric bus fleet and compare the operational data with a baseline diesel bus fleet. Model an electric public bus transportation system in a selected city.

**Accomplishments:** This project is completed and the final project report has been forwarded to DOT and the required DOT associated organizations. The project 14 final report is posted on the EVTC web site at: <http://fsec.ucf.edu/en/publications/pdf/FSEC-CR-2060-17.pdf>.

#### 15. Electric Vehicle and Wireless Charging Laboratory

**Objective:** Furnish, equip and operate an EV and Wireless Charging Laboratory within the FSEC laboratory facilities. This facility will function as a laboratory where EV vehicles are charged and discharged through a computer assisted communication network and where wireless chargers are evaluated.

**Accomplishments:** This project is completed and the final project report has been forwarded to DOT and the required DOT associated organizations. The project 15 final report is posted on the EVTC web site at: <http://www.fsec.ucf.edu/en/publications/pdf/FSEC-CR-2078-18.pdf>.

#### 16. Electric Vehicle Fleet Implications and Analysis

**Objective:** Evaluate the implementation and effectiveness of electrical vehicles used in fleet operations. The project will evaluate present usage through case studies. The results will be used to evaluate other vehicle applications and to determine how EV fleet adoptions could impact overall rates of market penetration and what are the programs or incentives that could encourage EV fleets.

**Accomplishments:** This project is completed and the final project report has been forwarded to DOT and the required DOT associated organizations. The project 16 final report is posted on the EVTC web site at: <http://evtc.fsec.ucf.edu/publications/documents/FSEC-CR-2031-16.pdf>.

#### 17. Electric Vehicle Energy Impacts

**Objective:** Evaluate the impacts of electric vehicles and associated renewable power generation on reduction of petroleum imports to Hawaii. The analysis will concentrate on the Island of Oahu and will include the effects of number of vehicles, charging strategies, renewable energy penetration levels and green-house gas reductions.

**Accomplishments:** This project is completed and the final project report has been forwarded to DOT and the required DOT associated organizations. The project 17 final report is posted on the EVTC web site at: <http://fsec.ucf.edu/en/publications/pdf/FSEC-CR-2063-17.pdf>.

#### 18. Socio-economic Implications of Large-scale Electric Vehicle Systems

**Objective:** Develop models to evaluate the socio-economic implications of a large-scale electrified transportation sector. Model factors include effects of vehicle and infrastructure safety requirements, standardization of vehicle components for safety and charging, electric vehicle supply and after-market economies, displacement of petroleum fuels and impacts of sustainable development (social, environmental and economic).

**Accomplishments:** This project is completed and the final project report has been forwarded to DOT and the required DOT associated organizations. The project 18 final report is posted on the EVTC web site at: <http://fsec.ucf.edu/en/publications/pdf/FSEC-CR-2073-17.pdf>.

## 19. Economic Impacts of Electric Vehicle Adoption

*Objective: Examine the predicted levels of electric vehicle adoption to analyze the opportunity of using EVs as a grid stabilization tool for Hawaii, including GHG emissions impacts. Assess factors that affect EVs adoption, including regulatory mechanisms.*

**Accomplishments:** This project is completed and the final project report has been forwarded to DOT and the required DOT associated organizations. The project 19 final report is posted on the EVTC web site at: <http://fsec.ucf.edu/en/publications/pdf/fsec-cr-2047-17.pdf>.

## 20. Techno-economic Analyses of Large-scale Electric Vehicle Systems

*Objective: Develop a computer model to evaluate the techno-economic implications of a large-scale electrified transportation sector. The model factors include developing a network of electric vehicles that interact with the electric grid, the infrastructure for electric vehicle charging, integrating the transportation and power systems into the urban setting, studying the impact of distributed energy storage and determining the economic impact of increased renewable energy and EVs on the grid.*

**Accomplishments:** This project is completed and the final project report has been forwarded to DOT and the required DOT associated organizations. The project 20 final report is posted on the EVTC web site at: <http://fsec.ucf.edu/en/publications/pdf/FSEC-CR-2071-17.pdf>.

## 21. Effect of Electric Vehicles on Power System Expansion and Operation

*Objective: Examine the effects of electric vehicles on electric power systems and their operation. This work includes using an existing Hawaii developed model that will be validated against a large scale utility model. The work will evaluate the benefits of optimally-timed EV charging, the requirements and costs of electric grid infrastructure to serve different types of vehicle fleets, and the effects of battery duty cycles used in the vehicle and in vehicle-to-grid applications.*

**Accomplishments:** This project is completed and the final project report has been forwarded to DOT and the required DOT associated organizations. The project 21 final report is posted on the EVTC web site at: <http://publications.energyresearch.ucf.edu/wp-content/uploads/2018/07/Hi-20-17.pdf>

## 22. Automated and Connected Vehicle Implications and Analysis

*Objective: This project will evaluate the usage and implementation of automated and connected vehicles (AV/CV). The project evaluation will be done through case studies with the results being applied to determine appropriate vehicle applications and how EVs will participate in this new transportation future.*

**Accomplishments:** This project is completed and the final project report has been forwarded to DOT and the required DOT associated organizations. The project 22 final report is posted on the EVTC web site at: <http://fsec.ucf.edu/en/publications/pdf/FSEC-CR-2065-17.pdf>.

## External Collaboration Accomplishments

### Key collaborations are:

1. City of Orlando – EVTC, Nissan North America and the City of Orlando discussed the development of a project to deploy electric passenger vehicles with V2G capability. The project objective was to begin testing the interconnection of battery electric vehicles with existing buildings. (Project 15)



## Education and Workforce Development Accomplishments

### University of Central Florida

The UCF Electrical Engineering Department offered multiple courses as undergraduate electives and entry-level graduate courses.

#### Spring 2018:

EEL 3290 Global energy issues

EEL 4294 Introduction to Smart Grid

#### Fall 2018:

EEL 4216 Fundamentals of Electric Power Systems

### University of Hawaii

#### Spring 2017:

ME 696 Innovations in Emerging Smart Electric Grid

EE 635 Smart Grids and Renewable Energy Integration

#### Spring 2018:

ME492 Special Topics in Mechanical Engineering

### Tuskegee University Battery Lab

Tuskegee University has completed the battery laboratory equipped with impedance analyzer, potentiostat, power supply and infra-red camera. This setup will enable students to investigate battery performance changes as well as the temperature effects of battery charging/discharging cycles. Specifically, electrode and electrolyte performances with degradation can be nondestructively characterized by using impedance spectroscopy. All of the results will ultimately augment the understanding of advanced battery chemistry to prepare students for future careers. The lab supports faculty and student lab experiments and student projects.

## Workforce Development

Nothing to report.

## Technology Transfer Accomplishments

Nothing to report.

## Diversity Accomplishments

Nothing to report.

## Metrics

Performance metrics for the EVTC project are designed to drive improvement and characterize progress and effectiveness. The metrics performance table for PPPR#9 is provided below.

| Metric       | Research Activities | Industry Collaboration | Educ. & Workforce Dev. | Tech. Transfer | Diversity |
|--------------|---------------------|------------------------|------------------------|----------------|-----------|
| Productivity | S                   | S                      | S                      | S              | S         |
| Timeliness   | S                   | S                      | S                      | S              | S         |
| Quality      | S                   | S                      | S                      | S              | S         |

NI - Needs improvement, S - Satisfactory, EG - Exceeds goals, or C - Completed.

In addition to the above metrics, a part of EVTC peer review has been the continued updating of each project's completion schedule and assistance in the writing of final project reports.

***What opportunities for training and professional development has the program provided?***

Nothing to report.

***How have the results been disseminated?***

Project results have been disseminated by presentations, publications and conferences.

**Final Research Project Reports:**

1. Kettles, C., "[Policies that Impact the Acceleration of Electric Vehicle Adoption](#)", FSEC-CR-2087-18, September 2018. *Project 2*.
2. Fripp, M., "[Intermodel Comparison Between Switch 2.0 and GE MAPS: Evaluating a New Tool for Integrated Modeling of Electric Vehicles and High-Renewable Power Systems](#)", HI-20-18, July 2018, *Project 21*

**Presentations:**

Nothing to report.

**Publications:**

Nothing to report.

***What do you plan to do during the next reporting period to accomplish the goals?***

All research and reporting has been completed.

**II. Products**

***List of products resulting from the program during the reporting period.***

The main focus of the EVTC project has been the completion of the final project reports. Two new final project reports have been completed and described in the section Final Research Project Reports.

**III. Participants & Collaborating Organizations**

***What organizations have been involved as partners?***

The three partner universities of the EVTC are the University of Central Florida's Florida Solar Energy Center and UCF's Civil, Environmental and Construction Engineering, Electrical Engineering and Computer Science departments, and the University of Hawai'i at Manoa and the Hawai'i Natural Energy Institute (HNEI) and Tuskegee University.

***What organizations have been involved as collaborative partners?***

The collaborative partners are presented in the External Collaboration Accomplishments section.

**IV. Changes/Impact**

During the period, two projects (numbers 2 and 21) were completed and the final project reports forwarded to DOT and the required associated organizations.

As of the date of this report all projects are complete.