EVTC™

Electric Vehicle Transportation Center

Semi-annual Program Progress Performance Report for University Transportation Center

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Semi-annual Program Progress Performance Report #9
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 completing of the 6 remaining final project research reports. During the period, four projects (numbers 8, 11, 12 and 15) were completed and the final project reports forwarded to DOT and the required associated organizations. Two additional final reports (numbers 2 and 21) are near completion.

For this reporting period, EVTC researchers finished 4 project final reports, authored 5 publication, made 1 poster presentation and 4 formal presentations and held or participated in 17 STEM events.

Research and Development Accomplishments

The EVTC R&D agenda has been conducting work on 22 projects. Sixteen are completed and the remaining six projects are conducting the final work efforts and are writing final project reports. 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 complete and a final project report is in progress.

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 now complete and a final project report is in progress. Following review, the final report will be submitted to DOT and posted on the EVTC and HNEI websites. The final report draft Abstract is as follows:

The project objective was to evaluate the economic benefits of scheduling EV charging at optimal times each day in the existing island of Oahu power system, and in a future power system with large renewable power inputs. In order to achieve this, the effects of EVs were examined on the island's electric power system design and operation. The work included expanding an existing Hawaii-developed utility model and validating it against an established utility-scale model, and concurrently evaluating the benefits of optimally timed EV charging.

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)
2. HNEI participated in the Hawaiian Electric Companies' Electrification of Transportation stakeholder workshop held in November 2017, and the Electric Power Research Institute's National Electric Transportation Infrastructure Working Council Symposium held in February/March 2018, hosted by the Hawaiian Electric Companies. (Project 17).

Education and Workforce Development Accomplishments

University of Central Florida

The UCF Department of Civil, Environmental, and Construction Engineering (CECE) offered one course in the spring quarter 2017 taught by UTC project faculty:

CCE 3930H – Systems Analysis for Sustainability: Introduction to the principles of sustainable engineering; the use of systems thinking and life-cycle thinking in understanding sustainable systems. Development of sustainability metrics; applications to sustainable transportation, energy-transportation nexus, and electric vehicles.

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

Spring 2018:

EEL 3290 Global energy issues

EEL 4216 Fundamentals of Electric Power Systems

EEL 4294 Introduction to Smart Grid

EEL 5937 Advanced Microgrid Design and Operation

EEL 6269 Advanced Topics in Power Engineering

EEL 6712 Modeling and Analysis of Networked Cyber-Physical Systems

Fall 2018:

EEL 4216 Fundamentals of Electric Power Systems

EEL 4XXX Introduction to PVEEL 4XXX Power System Economics

EEL 5255 Advanced Power Systems Analysis

EEL 5268 Communications and Networking for Smart Grid

EEL 6XXX Power System Resilience

University of Hawaii

Spring 2018:

The UH College of Engineering offered one course in the spring semester 2018 taught by UTC project faculty:

ME492 Special Topics in Mechanical Engineering

The purpose of this class is to provide a basic understanding of electrochemical power systems (batteries, fuel cells and supercapacitors) to prepare students for work in the field of renewable energies. The class provides an education on the main aspects necessary to safely choose, design and operate electrochemical

power sources for different applications. This features material science, process, testing, assembly and controls. Additionally, the core principles of electrochemistry, the history of electrochemical power sources, their sustainability and their potential impact in Hawaii are covered.

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.

A student was able to record the Electrochemical Impedance Spectroscopy (EIS) spectrum of the battery in different state of charge condition and get training by using the procured instrument. Results were presented in 95th annual meeting held of Alabama Academy of Science (AAS) at Samford University Birmingham (March 14-16, 2018). Further educational and outreach activity is on progress. As a part of outreach activity, we are making initial efforts to host 96th annual meeting of AAS in 2019 at Tuskegee University.

Workforce Development

As part of the STEM program and STEM presentations, staff has investigated career opportunities related to EVs. The EVTC has also partnered with the Central Florida Clean Cities Coalition on several workforce initiatives that have been offered in partnership with Florida workforce agencies.

Technology Transfer Accomplishments

As previously reported, UCF and the Central Florida region have established extensive business incubator style programs. The two major programs are the Innovative Corps, an NSF funded effort, and the high-tech BRIDG research center near Kissimmee, FL. (The BRIDG center stands for Bridging the Innovation to Development Gap and it was previously called the Florida Advanced Manufacturing Research Center.) BRIDG opened its doors in March 2017 and is a 109,000 square-foot research and manufacturing facility. BRIDG goals are to attract pioneer manufacturing processes and materials designed to advance the production of smart sensors and photonics devices.

Diversity Accomplishments

University of Central Florida -- The primary components of the EVTC diversity program efforts are university education, STEM and K-12 activities, which include curriculum development, professional development for educators and education and outreach to students from underserved communities.

The EVTC program includes STEM project-based learning activities which have an EV focus. Two of the programs are the Junior Solar Sprint (JSS) for fourth through eight graders and the Electrathon program, which targets high school and college level students. Efforts have further expanded to provide STEM education opportunities that have an EV focus to underserved and under-represented students include the development of a JSS guide book, as well as mentoring and technical assistance to afterschool clubs and groups for JSS and Electrathon. We are piloting a specific approach to deploy Junior Solar Sprint in afterschool settings for underserved and under-represented student in STEM and for dependents of military personnel. This was possible due to funding FSEC received from the Army Education Outreach Program (AEOP). The specific program developed by FSEC and the National Renewable Energy Laboratory (NREL) includes professional development for educators working with the targeted student population; providing resources such as materials, tools and car kits; offering onsite technical assistance

to those working with the students; and providing a venue for the students to "show what they know" at a culminating event or competition.

Through a partnership with the Plug-in Hybrid Electric Vehicle Center (PHEV) at the University of California – Davis, FSEC developed a hands-on, high school level set of curricular activities, *Electrifying Transportation*, and conducted a professional development workshop for teachers in October, which introduced the curriculum unit and modeled how to implement the activities with their students.

Professional development opportunities are offered to teachers and after school program leaders interested in implementing the EV focused, STEM programs. Efforts to work with the 21st Century Community Learning Centers (CCLC) and Florida After-School Association continue. Although the organizations are interested in partnering, it continues to be a challenge to schedule the necessary professional development for these educators due to staffing and time constraints. FSEC staffers have made resources available to these organizations, as well as offered technical assistance in order to implement these activities within Brevard County. FSEC continues to work with STEM Tech Neighborhood Academy and is working with Brevard County Public Schools (BCPS) After School programs. The focus for the BCPS is the implementation of JSS in an after school program at a local school with a large population of underserved students.

Education and EV outreach events, occurred in various parts of Florida. A curriculum which introduces high school students to electric vehicles was developed. At a teacher workshop held in conjunction with the Florida Association of Science Teachers Conference was offered. This offered teachers an opportunity to learn about electric vehicles and do hands-on activities taken from the curriculum. Dr. Tom Turrentine from UC-Davis presented the latest research on EVs and answered questions as part of the workshop. Orlando Utilities Commission and FSEC provided EV's for teachers to physically explore and drive as part of the experience. Two additional presentations were offered, another at FAST and a second at the National Science Teacher Association Conference in Georgia. The science teachers in attendance, most of them environmental, technology or physics teachers were very interested in the environmental implications of EV's.

FSEC continues to prepare for EnergyWhiz, which is a large outreach event that includes several electric vehicle focused activities for students.

EV curriculum development includes both the JSS and Electrathon programs. A video on how to evaluate design components of a JSS vehicle was created at FSEC and is available upon request. A supplemental electric vehicle curriculum for high school students is nearing completion. Select activities from the curriculum will be implemented with teachers at the Florida Association of Science Teachers Conference in Orlando on October 19, 2017. Feedback from teachers will be included in revisions to ensure the curriculum and activities are user-friendly and adequately reflect science teaching standards.

List of STEM Activities:

1. October 4, 2017, Saturn Elementary Afterschool Program (SEAP) – 27 students introduced to EV technology through the Junior Solar Sprint (JSS) program
2. October 19 - 21, 2017 – Florida Association of Science Teachers (FAST) Conference Electrifying Transportation Workshop held on October 19, Presentation on EVs given on October 20 Approximately 25 teachers participated in the workshop & presentation, 1000 teachers attended the conference.
3. October 30, 2017 – Eastern Florida State College students at FSEC for presentation and tour. Focus on EVs and solar technology. 30 students participated.
4. November 1, 2017 – SEAP – students continue to work on building JSS vehicles. November 14, 2017 – Milwee Middle School Girls STEM club visits FSEC in Cocoa. JSS information distributed. Approximately 35 girls participated.

5. December 3, 2017 – Junior Solar Sprint (Electric Vehicle) workshop for teachers held in St. Petersburg, FL. Workshop funded by Duke Energy. Approximately 10 teachers participated.
6. January 10 & 11, 2018 – Brevard County Public Schools Science Teacher workshop at FSEC, Cocoa– Information about JSS & Electrathon programs distributed to 80 teachers.
7. January 20, 2018, – Junior Solar Sprint (Electric Vehicle) car building workshop at FSEC, Cocoa for 25 teachers. .
8. January 25, 2018 – Brevard County After School Educators Meeting in Cocoa. . Approximately 30 educators participated.
9. February 17, 2018 – STEM & Solar Expo in Pinellas County, JSS competition and solar array dedication ceremony. Approximately 75 students, teachers and the public participated.
10. February 23, 2018 – Provided JSS track and racing materials to Technology Student Association (TSA) for the regional JSS event in Orlando, FL. Approximately 200 students participated.
11. March 1, 2018 – Meeting with STEM Tech Neighborhood Academy board and volunteers regarding JSS event and resources to be held in Melbourne in April. 10 people in attendance.
12. March 3, 2018 – EnergyWhiz Expo in Tallahassee in collaboration ReThink Energy and the Florida Energy Office, within the Fl. Department of Agriculture and Consumer Services. A JSS competition was held for elementary and middle school students as part of the activities. Approximately 100 students, teachers, parents and the public attended.
13. March 19, 2018 – Meeting with Brevard County Public Schools (BCPS) regarding EV's for Drivers Education. Two EV's have been purchased by BCPS. FSEC will provide assistance with curriculum and outreach activities to BCPS. March 24, 2018 – EnergyWhiz Expo, Brandon, FL. Junior Solar Sprint competition held for elementary and middle school students. Approximately 100 participants.
14. April 9, 2018 - Eastern Florida State College students at FSEC for presentation and tour. Focus on EVs and solar technology. 25 students participated.
15. April 28, 2018 – STEM Tech Neighborhood Academy JSS competition. Approximately 75 attendees.
16. May 3, 2018 – Saturn Elementary Afterschool Junior Solar Sprint competition. Approximately 70 attendees.
17. May 12, 2018 – EnergyWhiz at FSEC. Six energy focused competitions for students. Electrathon and Junior Solar Sprint among those offered. 1000 attendees.

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	EG	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?

Training and professional development activities have been provided to students, industry professionals and the public by the three partner universities. These activities have been previously presented in the

Education and Workforce Development Accomplishment sections above and in the following section of results dissemination.

How have the results been disseminated?

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

Final Research Project Reports:

1. Sariri, S., Schwarzer, V., Ghorbani, R., "Electric Vehicle Interaction at the Electrical Circuit Level", FSEC-CR-2077-18, January 2018. *Project 12*.
2. Raustad, R., "Electrical Vehicle Grid Experiments and Analysis," FSEC-CR-2076-18, February 2018, *Project 11*
3. Raustad, R., Wilson, W., "Electric Vehicle and Wireless Charging Laboratory," FSEC-CR-2078-18, March 2018, *Project 15*.
4. Brooker, P., Qin, N., Dubarry, M., "Battery Technologies for Mass Deployment of Electric Vehicles", FSEC-CR-2079-18, April, 2018. *Project 8*.

Presentations:

1. A. Devie, G. Baure and M. Dubarry, "Durability and Reliability of EV Batteries under Electric Utility Grid Operations: Bidirectional Charging Impact Analysis", 232th Electrochemical Society Meeting, National Harbor, MD, USA, Oct. 2017. *Project 9.*
2. K. McKenzie, "Hawaiian Island EV-Grid Integration," EVs & the Grid 2017 Summit, San Francisco, Oct. 17-19, 2017. *Project 17.*
3. M. Dubarry and K. McKenzie, "Hawaii Energy and the Role for Storage", American Chemical Society Hawaii, Local Section Election Luncheon, Honolulu, HI, Nov. 2017. *Project 9 and 17.*
4. Salah Elafandi, Akshaya Kumar, Prakash Sharma, Tuskegee University, "Measurement of Impedance of Lithium Ion Battery using Electrochemical Impedance Spectroscopy", Poster, Alabama Academy of Science annual meeting, Stamford University, Birmingham, AL. March 14-16, 2018.
5. Brooker, P., "Battery Technologies for Mass Deployment of Electric Vehicles," Renewable Energy and Sustainability Conference, Polytechnic University, July 31 – August 1, 2017. *Project 8. Previous reporting period*.

Publications:

1. Azwirman Gusrialdi, Zhihua Qu and Marwan A. Simaan, ``Distributed Scheduling and Cooperative Control for Charging of Electric Vehicles at Highway Service Stations," IEEE Transactions on Intelligent Transportation Systems, vol.18, no.10, pp. 2713-2727, October 2017.
2. Kotub Uddin, Matthieu Dubarry, Mark B. Glick, "The viability of vehicle-to-grid operations from a battery technology and policy perspective", Energy Policy, Vol. 113, Pages 342-347, Feb. 2018. *Project 9.*
3. Matthieu Dubarry, George Baure, and Arnaud Devie, "Durability and Reliability of EV Batteries under Electric Utility Grid Operations: Path Dependence of Battery Degradation", Journal of The Electrochemical Society, 165 (5) A773-A783 (Mar. 2018). *Project 9.*
4. Hamed Valizadeh Haghi and Zhihua Qu, ``A Kernel-Based Predictive Model of EV Capacity for Distributed Voltage Control and Demand Response," IEEE Transactions on Smart Grid, to appear 2018.
5. Miyu Yoshihara, Toru Namerikawa, Zhihua Qu, "Non-Cooperative Optimization of Charging Scheduling of Electric Vehicle via Stackelberg Game," submitted to the 2018 SICE Annual Conference, Nara Kasugano International Forum, Nara, Japan, 2018.

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

The R&D program and the research accomplishments for each of the 22 projects are presented in the Accomplishments section. For all active projects, future activities are presented as part of the accomplishments. As previously noted twenty projects are completed and have the final reports posted. Final reports for the other two projects are being drafted.

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. Four new final project reports have been completed and described in the section Final Research Project Reports. Additionally, an EV curriculum, *Electrifying Transportation* was developed as well as a professional development workshop for high school teachers. Numerous STEM events occurred as described in the section List of STEM activities.

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, four projects (numbers 8, 11, 12 and 15) were completed and the final project reports forwarded to DOT and the required associated organizations. Two additional final reports (numbers 2 and 21) are close to being completed.

As of this time the project is nearly out of funding resources and minimal continuing support will be supplied by FSEC.