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 #8
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 final project research reports. During the period, twelve projects (numbers 3, 4, 5, 7, 9, 10, 13, 14, 17, 18, 20 and 22) were completed and the final project reports forwarded to DOT and the required associated organizations. Two additional final reports (numbers 12 and 21) are close to being completed. Final reports for the other 4 remaining projects (numbers 2, 8, 11 and 15) are in various stages of completion.

For this reporting period, EVTC researchers finished 12 project final reports, authored 1 publication, made 4 presentations and held or participated in 8 STEM events.

Collaborative efforts for the period included a meeting with GE Energy Management regarding grid management plans for Hawaii, the City of Orlando to discuss the development of a network of smart EV charging stations and a planning effort with Orlando Utilities Commission to develop a scoping document for renovation of an unused building for research and development of EV car and bus applications, use of fuel cells for alternative energy production, building energy efficiency measures, and general public awareness activities.

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 continuing to collect data 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 has continued to address the economic impact of EVs in vehicle-to-grid (V2G) applications. While several models have been presented that simulate V2G activities, there is a limited supply of real-world data that could validate these models. During the current reporting period, a communication and control algorithm was developed and implemented which will enable a Nissan Leaf to export power to the local grid according to signals from the building energy management system. Utilizing this control algorithm, the battery in the Leaf can be charged or discharged on demand, and the impact of the V2G activities on the building's electricity costs will be assessed. The control algorithm is operating and continues to be refined. Currently, the control algorithm is attempting to reduce the building's peak demand, and analysis of the demand on the battery is ongoing.

Using data from this real-world example, potential opportunities for V2G activities that directly support the grid (e.g. voltage support and frequency regulation) will be identified, and revenue streams will be estimated. Potential impacts on battery durability will also be evaluated.

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 now complete and a final project report is in progress. Following review, the final report will be posted and submitted to DOT.

The final report draft Abstract is as follows:

This project has conducted vehicle-to-grid (V2G) experiments and has developed a low cost building energy management system (EMS). The V2G efforts also included the installation and operation of a Princeton Power System CA-30 bi-directional power system. These efforts were conducted in order to collect real data that could then be applied to conducting V2G experiments. The collection of building energy data was used to evaluate and verify development of a low-cost power management system. The EMS was directed toward reducing peak electrical demand for a commercial office building.

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 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 impacts of electric vehicles (EVs) on the electricity distribution grid was studied starting with development of a transient time domain model of a sub-circuit service area with PV power using EV charging as a means of mitigating transient over-voltages (TOVs) in various scenarios. This novel methodology for early detection of TOVs has shown that charging stations combined with the connected grid load of the EV can be used to eliminate over-voltage peaks and improve the response time and reliability of inverter-based islanding detection, thus, increasing grid reliability.

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 now complete and a final project report is in progress.

During this reporting period the Princeton Power System 30 kVA bi-directional power supply has been deployed to investigate building electricity power control to minimize electricity costs. See Project #8 description.

Figure 1. PPS CA30 in EVTC lab

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, then 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. Drive Electric Florida - EVTC worked with Drive Electric Florida on the development of Volkswagen Mitigation Trust Fund infrastructure project recommendations for the Florida Chamber of Commerce, and a separate initiative to introduce EV transportation and land use planning to governmental representatives at the state capital in Tallahassee (Project 2 and 4).
2. City of Orlando - EVTC, the City of Orlando and University of Hawaii discussed the development of a project to deploy electric passenger vehicles with controlled charging coordinated with a City of Orlando building energy management system. The project objective was to reduce overall energy consumption and electricity costs with initial testing and commissioning at the FSEC EV and Wireless Charging Laboratory. Monitoring the battery state of health was also discussedin order to

enhance overall project economics and the value of a combined electrified transportation and building energy management system. (Projects 9 and 15)

3. GE Energy Management, Energy Consulting - Steering committee meeting was held with HNEI, UH, Hawaiian Electric Company and other stakeholders for the HNEI-GE high fidelity grid modeling. (Project 17).
4. The Orlando Utilities Commission (OUC) requested a scoping document to outline potential use of the abandoned Ivanhoe building which is owned by OUC and located in Orlando, Florida. The scoping document, prepared by FSEC, outlined laboratory and interdisciplinary programs for joint use between OUC and UCF. Some of the suggested programs include grid-scale energy storage (Projects 8 and 11), electric vehicles (Projects 14, 15 and 21), smart grid integration (Project 22), fuel cells (Project 10) and building energy management (Project 3).

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 five courses as undergraduate electives and entry-level graduate courses.

Spring 2017:

EEL 5291 Distributed Control and Optimization for Smart Grid
EEL 6272 Smart Power Grids Protection
EEL 3290 Global energy issues
EEL 4216 Fundamentals of Electric Power Systems

Fall 2018:

EEL 5268 Communications and Networking for Smart Grid

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

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.

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 has been difficult 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. EnergyWhiz Expos and the EnergyWhiz statewide event reached well over 1000 students and teachers throughout Florida. The smaller EnergyWhiz Expos were held in Tallahassee, Parrish, Tampa, Lake Nona and Gainesville. Each of the five EnergyWhiz Expos included Junior Solar Sprint competitions. The statewide EnergyWhiz event was held on May 13, 2017, at the Florida Solar Energy Center in Cocoa. This STEM-centered event included several EV events, including JSS, Electrathon and an Electric Vehicle showcase. The Electrathon of Tampa Bay group continues as a partner to engage more students in the Electrathon program.

The UCF Electrathon team participated in the EnergyWhiz event at FSEC on May 13, 2017. The team continues to make improvements to their vehicle. They are scheduled to participate in races throughout Florida and Georgia during the 2017 – 2018 school year and act as spokes persons for EV technology. The UCF team will be assisting the STEM Tech Neighborhood Academy as they design and build an Electrathon vehicle to compete in the 2018 EnergyWhiz event at FSEC.

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. April 1, 2017 – Central Florida EnergyWhiz Expo, Lake Nona High School, Approximately 200 students and teachers attended.
2. April 3, 2017 – Eastern Florida State College students at FSEC for presentation and tour. Focus on EVs and solar technology. 25 students participated.
3. April 8, 2017 – North Central Florida EnergyWhiz Expo, Gainesville Raceway. Approximately 125 students and teachers participated.
4. May 13, 2017 – EnergyWhiz at FSEC. Approximately 1000 students, teachers and the public participated.
5. June 23 & 24, 2017 – National JSS competition, Technology Student Association Conference, Orlando. Approximately 300 students participated.
6. July 12 & 13, 2017 – Florida Energy Workforce Consortium (FEWC) Meeting and Workshop, Kissimmee, 120 participants.
7. September 23, 2017 – Research Rules! Student Conference, Viera, FL., Approximately 130 students, teachers and parents participated.
8. September 28, 2017 – Fl. After School Alliance Conference, Orlando, FL. Approximately 40 educators participated.

Metrics

Performance metrics for the EVTC project are designed to drive improvement and characterize progress and effectiveness. The metrics performance table for PPPR#8 is provided below.

Metric	Research Activities	Industry Collaboration	Educ. & Workforce Dev.	Tech. Transfer	Diversity
Productivity	EG	S	S	EG	EG
Timeliness	S	S	S	S	S
Quality	EG	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, workshops and conferences.

Final Research Project Reports:

1. Qin, N., Brooker, R. P., Raissi, A., "Electric Bus Systems", FSEC-CR-2060-17, April 2017. *Project 14.*

2. McKenzie, Katherine, "Electrical Vehicle Energy Impacts," FSEC-CR-2063-17, May 2017, *Project 17*
3. Dubarry, Matthieu, "Electric Vehicle Battery Durability and Reliability Under Electric Utility Grid Operations," FSEC-CR-2064-17, May 2017, *Project 9.*
4. Block, D., Raustad, R., "Automated and Connected Vehicle Implications and Analysis," FSEC-CR-2065-17, May 2017, *Project 22*.
5. Block, D., Raissi, A., Raustad, R., "Transportation Planning for Electric Vehicles and Associated Infrastructure," FSEC-CR-2068-17, May 2017, *Project 4*.
6. Block, D., Brooker, P., "Prediction of Electric Vehicle Penetration," FSEC-CR-2069-17, May 2017, *Project 5*.
7. Qu, Z., Gusrialdi, A., "Optimal Charging Scheduler for Electric Vehicles on the Florida Turnpike," FSEC-CR-2070-17, June 2017, *Project 13*.
8. Qu, Z., "Techno-Economic Analysis of Large-Scale Electric Vehicle Systems," FSEC-CR-2071-17, June 2017, *Project 20.*
9. Tatari, O., "Socio-economic Implications of Large-scale Electric Vehicle Systems," FSEC-CR-2073-17, July 2017, *Project 18*.

Presentations:

1. Towfiq Rahman and Zhihua Qu, "The Role of Electric Vehicles for Frequency Regulation during Grid Restoration," 2017 IEEE PES General Meeting, 17PESGM2155, Chicago, IL, USA, July 16-20, 2017.
2. Farzad Aalipour, Azwirman Gusrialdi, and Zhihua Qu, "Distributed Optimal Output Feedback Control of Heterogeneous Multi-agent Systems under a Directed Graph," The 20th World Congress of the International Federation of Automatic Control, Toulouse, France, July 9-14, 2017
3. Towfiq Rahman, Roland Harvey, Zhihua Qu*, Marwan A. Simaan, "A Distributed Cooperative Load Control Approach for Ancillary Services in Smart Grid", the 2017 American Control Conference, Sheraton Seattle Hotel, May 24-26, Seattle, WA, USA.
4. K. McKenzie, "Hawaiian Island EV-Grid Integration**",** presentation accepted for EVs & the Grid 2017 Summit, Oct. 17-19, San Francisco, CA.

Publications:

1. K. McKenzie, "EV Charging Stations," *Building Industry Hawaii*, and *Building Management Hawaii, (to press March 20, for publication April 2017). Project 17*

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 sixteen projects are completed and have the final reports posted. Final reports for the other six projects are being drafted or are in various stages of completion.

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. Nine new final project reports have been completed and described in the section Final Research Project Reports. Additionally, eight STEM events were held this reporting period 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.

The primary collaborators this reporting period have been General Electric Corporation, Orlando Utilities Commission, the City of Orlando and Drive Electric Florida.

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, twelve projects (numbers 3, 7, 10, 14, 17, 9, 22, 4, 5, 13, 20 and 18) were completed and the final project reports forwarded to DOT and the required associated organizations. Two additional final reports (numbers 12 and 21) are close to being completed. Final reports for the other 4 remaining projects (numbers 2, 8, 11 and 15) are in various stages of completion.

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

Administrative change during the period has been the adding of Richard Raustad as the project PI.