



Electric Vehicle Transportation Center

Semi-annual Program Progress Performance Report for University Transportation Systems

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A handwritten signature in black ink, appearing to read "David Block", is written over a white background.

**Semi-annual Program Progress Performance Report for
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's (EVTC) vision is to transform the country's transportation network into a fully integrated "smart" electric vehicle deployment system coupled with a "smart" electric grid achieved with maximum efficiency and minimum time and disruption.

To accomplish the EVTC vision, the Center's goals are to serve as the focal point for 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 will evaluate technologies, standards and policies to ensure seamless integration of EVs into a complex electricity grid and transportation network. The EVTC will bridge the gap between deployment of electric vehicles and the traditional transportation system.

To meet the EVTC's goals the EVTC will undertake five activities as follows: Research and Development, Industry Collaboration, Education and Workforce Development, Technology Transfer and Diversity.

Research and Development

The R & D program uses a layered structure consisting of technical sub-tasks leading to the final desired output. There are four technical sub-tasks covering the areas of policies, standards, sub-systems, and electric vehicle supply equipment analysis. These four sub-tasks feed into the three major outputs of specialized EV applications, large-scale social-economic implications and large-scale techno-economic systems and analysis.

Industry Collaboration

Commercial adoption of the advanced technologies developed at the EVTC will require partnerships with a variety of external groups. For this reason, the EVTC has begun to collaborate with national groups (National Renewable Energy Laboratory, Electric Power Research Institute), with numerous private utility companies (Duke Energy Florida, Florida Power and Light, Orlando Utilities Commission) and with transportation groups/agencies (Florida Department of Transportation, Florida Turnpike Authority, Tallahassee StarMetro Bus System). Additional partnerships are developing as our work progresses.

Education and Workforce Development

The EVTC's integrated approach to education brings the experience and capabilities of three top university programs to develop and offer undergraduate and graduate engineering and science-based transportation system educational programs. Students receiving degrees or training from any of the three universities will be well prepared and an asset to the future U.S. workplace. Educational activities include short courses, K-12 education and science, technology, engineering and mathematics (STEM) based programs and careers.

In the workforce development area, the University of Central Florida (UCF) will develop, in close cooperation with state and local workforce agencies, a variety of job stimulation and training initiatives. Current efforts include specialized and customized training for new and incumbent workers in the clean energy field. The Central Florida Clean Cities Coalition will also play a major role in workforce development efforts using U.S Department of Energy approved curriculum for training new and incumbent workers. The EVTC will also foster the growth of new business development using the UCF incubator and Angel Network programs.

Technology Transfer

The EVTC will conduct technology transfer through participation in professional society meetings and conference presentations, professional and scholarly publications, industry and consumer literature development, and outreach using conventional and social media.

Diversity

The EVTC team members are a well-rounded and diverse group with an extensive range of expertise and capabilities. The EVTC's commitment to enhance diversity in the transportation field is demonstrated by partnering with Tuskegee University, a Historically Black College and University (HBCU)/minority serving institution and with the University of Hawaii, a Native Hawaiian-Serving Institution. We will further our diversity efforts by recruiting and developing new scientific and technical staff to include an emphasis on students.

Metrics

Performance metrics for the EVTC program are designed to drive improvement and characterize progress and effectiveness. The metrics are applied to enhance performance improvements, efficiency, and appropriate levels of internal controls. They will incorporate "best practices" related to the performances being measured and cost/risk/benefit analysis, where appropriate. Each of the above goals and activities are to be measured against the following metrics table:

	Research Activities	Industry Collaboration	Educ. & Workforce Dev.	Tech. Transfer	Diversity
Productivity					
Timeliness					
Quality					

The evaluation criteria are productivity, timeliness and quality of the project tasks – as they are applied to EVTC research activities, industry collaboration, education and workforce development, technology transfer, and diversity. In each box within the metric table the following ranking will be applied:

- Needs improvement (NI)
- Satisfactory (S)
- Exceeds goals (EG)
- Completed (C)

Any item receiving a Needs Improvement will require more definition between the reviewing parties and the item or organization being reviewed.

In addition to the metrics, a part of EVTC peer review and best practices procedures is the guidance by a Steering Committee, comprised of the UCF PI (the EVTC Director), UCF Co-PIs and the PIs from the two partner universities. This five-member Steering Committee is responsible for overall direction and oversight, and has decision-making authority on all EVTC program activities. The Steering Committee will evaluate all EVTC projects and incorporate input from an external Oversight Committee in its decisions. The EVTC Oversight Committee has been established and its members are:

- Darryll Dockstader, Research Center Manager, Florida Department of Transportation, Tallahassee, FL
- Mike Faas, Sr. Project Manager, Facilities Administration, Publix Groceries, Lakeland, FL
- Britta Gross, Director, Advanced Vehicle Commercialization Policy, General Motors, Orlando, FL
- George Hutchinson, Sr. Director, Power and Energy, Concurrent Technologies Corp., Arlington, VA
- Jenny Liu, Assistant Professor, Dept. of Civil and Environmental Engineering, University of Alaska, Fairbanks, AK
- Helda Rodriguez, President, NovaCharge Inc., Oldsmar, FL
- Lisa Rice, CareerSource Brevard, Rockledge, FL
- Jennifer Szaro, Orlando Utilities Commission, Orlando, FL

- Thomas Wilke, Business Development and Concessions Manager, Florida Turnpike Enterprise, Ocoee, FL

What was accomplished under these goals?

Research and Development Accomplishments

The major research accomplishments during the first six-month period were the development and refinement of the research agenda in coordination with the research faculty and partners. The result was the identification of 21 individual research projects that address technical, economic and policy aspects of an electric vehicle transportation system. The work on these projects is in the beginning stages with literature reviews serving as the primary results and accomplishments. The following section presents the 21 projects with each project objective and a summary of results to date.

POLICIES

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: Reviewed existing industry and government reports detailing current and future predicted fuel tax revenues for the federal highway programs and impacts and shortfalls to highway funding as a result of EV market penetration. Compiled 10 year history of US fuel revenues and analyzed to predict revenue shortfalls in the event EV sales have major current and future impacts on revenues. The analysis shows that current trends in EV sales can result in a 41% decrease in tax revenues (A more detailed report will be prepared for future publication.). Ongoing review of US government, state and local laws and initiatives and policies to increase revenue streams from increased EV market share is being conducted.

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. This work will include a review of initiatives that have the effect of both encouraging and discouraging the deployment of electric vehicles.

Accomplishments: Conducted a literature review of state and federal legislative initiatives and developed a compendium for further analysis.

STANDARDS

3. Electric Vehicle Charging Technologies and Analysis

Objective: Assess existing electric vehicle charger hardware and software, design, standards,

and costs. Identify requirements of emerging technologies and applications. Identify and recommend policies and best practices that advance electric vehicle charging technologies and deployment.

Accomplishments: Currently working with national, regional, and local EV car manufacturers/dealers to understand the general desire of customers for charging at residential, public, and workplace locations. Developed contacts with charger companies to accelerate product penetration in Florida. Continuing dialogues with energy providers regarding electrical grid demand load due to the presence of both level II and DC fast chargers.

4. Electric Vehicle and Infrastructure Safety Requirements and Regulations

Objective: Evaluate current and proposed electric vehicle and infrastructure safety standards and policies with respect to cost and applicable codes, and regulations. The results will be used to evaluate the effects of policies/regulations and on the advancement of electric vehicles and supply equipment.

Accomplishments: Completed a literature search of codes and standards typically used for US electric vehicle and infrastructure projects. The codes and standards are applicable to vehicle systems, batteries, interface and infrastructure. The literature search also included a review of conference proceedings and other commentary on electric vehicle codes and standards that will be used in the future evaluation process.

SUB-SYSTEMS

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 project electric vehicle sales and sales characteristics within the U.S. Provide projections of sales through the year 2024 for the states of Florida, Hawaii, Alabama, Georgia, California and New York.

Accomplishments: Predicted values of PEV yearly sales and cumulative sales have been collected based on 2013 data. As additional sales data are received, the results will be updated. The results for the U.S. show that cumulative sales of EVs through 2013 was 167,600 vehicles with 96,700 sold in 2013. In other words, 58% of total electric vehicle sales were in 2013. Depending on the escalation rate selected, the 10 year future U.S. sales (2023) are predicted to be from 250,000 to 1.9 million per year and the cumulative vehicles on the roads will be from 1.9 to 7.3 million vehicles. Comparing the collected results with predictions from other sources, a growth rate of 20% appears to be most appropriate. A 20% growth rate will give U.S. sales of approximately 600,000 PEVs per year and cumulative sales of 3.2 million PEVs for 2023. This same 20% growth rate will give PEV sales in Florida, Hawaii and Alabama of 46,000, 11,000 and 6,000, respectively. The cumulative PEV sales for these three states are 241,000, 58,000, and 32,000 vehicles. California is predicted to sell 186,000 PEVs per year with cumulative sales of 935,000 PEVs.

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: Preliminary efforts include the review of existing electric vehicle economic analysis tools. The vehicle cost calculator found on the U.S. DOE Alternative Fuels Data Center web site will be used as a guide for mileage and fuel use. Additional resources identified include the Kelly Blue Book web site providing total cost of ownership and an Electric Power Research Institute report on the life cycle costs of electric vehicles.

7. Assess the SunGuide and STEWARD Databases

Objective: Evaluate the feasibility of using the existing Florida Department of Transportation SunGuide[®] software and STEWARD data base as platforms for analyzing the attributes of electric vehicles within present and future transportation infrastructure.

Accomplishments: The documentation for accessing and interpreting the Florida based SunGuide and STEWARD databases has been procured and reviewed. Future efforts will identify available vehicle information (e.g., number of vehicles, vehicle speed, etc.) for use in EVTC simulation projects.

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: Literature on battery state-of-the-art, testing protocols and lifetime analysis has been reviewed. After discussions among the task researchers, the immediate future efforts are to improve information dissemination regarding the various battery chemistries in use or under investigation. This will be accomplished through developing a website that will compile research on the components within Li-ion batteries, complete with article references. Additional efforts will be devoted to identifying relevant standards for transporting batteries, as well as determining battery lifetime as a function of operating temperatures.

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 first phase has been spent collecting information on the battery state-of-the-art degradation studies and on cell selection. Results have identified two target

battery chemistries – one a LiFePO₄ based battery and the other manganese / cobalt / nickel base chemistry. A manufacturer for EV applicable graphite / LiFePO₄ cells was selected. The next steps will be the selection of the manufacturer for the second selected battery chemistry and drafting a review paper.

10. Fuel Cell Vehicle (FCV) Technologies, Infrastructure and Requirements

Objective: Identify state-of-the-art fuel cell technologies and vehicles and current infrastructure requirements. A comparison with DOE targets for fuel cell vehicles and components will be included.

Accomplishments: The paucity of hydrogen infrastructure presents a major challenge for FCV commercialization. Two feasible types of hydrogen fueling stations have been identified: (1) stations relying on hydrogen produced in centralized locations and delivered; (2) stations with onsite hydrogen production from water electrolyzers or steam methane reformers. The choice of hydrogen fueling station types will need to be based on location and demand. A cost analysis of hydrogen fueling stations has shown cost reductions will be achieved via lowering component costs, standardizing station design and increasing station capacity. The most feasible hydrogen infrastructure rollout strategy is to introduce both hydrogen vehicles and refueling stations in a limited number of geographic areas where early adopters are concentrated. A report has been drafted and will be posted on the EVTC web site which analyzes key aspects of hydrogen infrastructure and summarizes the leading research efforts in academia, industry, and government agencies. These results will assist FCV stakeholders to take the right steps toward strategic buildup of hydrogen infrastructure and spur FCV market entry. It is noted that with three major automakers (Honda, Hyundai, and Toyota) planning to introduce consumer Fuel Cell Electric Vehicles (FCEVs) by 2016.

The project also identified the following future activities. Work will be performed on a case study of a fuel cell/battery hybrid bus recently acquired by NASA - Kennedy Space Center. This work will evaluate fuel cell system efficiency, range, durability, and lifespan given current catalyst, membrane and hydrogen storage system technologies. The work will also identify obstacles for mass production, compare the “well to wheel” hydrogen production cost, compare GHG emissions to other fuels and collate data to project ownership costs of FCEVs.

ELECTRIC VEHICLE SUPPLY EQUIPMENT ANALYSIS

11. Electric Vehicle Grid Experiments and Analysis

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

Accomplishments: V2G experiments have been defined and anticipate using facilities at FSEC to conduct these experiments. There are approximately 30 kW of photovoltaic (PV) panels that are presently under test, but are not connected to the grid; one of three highly instrumented residential test homes; and, the FSEC main office building, which may serve as a commercial office facility. The project identified future work of conducting preliminary vehicle-to-grid (V2G) experiments using an FSEC test residence augmented with 10 kW of

PV and/or V2G experiments using the FSEC office building augmented with 15kW of PV. Experiments may include storage to simulate secondary use applications for discarded EV batteries. Activities include working with stakeholders to acquire instrumentation, batteries, EV battery test stands and V2G inverters for these projects.

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 first phase of the project has collected information on different types of batteries and on electric vehicle chargers (type, rating, programmability). Results have identified available EV chargers with their type, rating, programmability and names of major manufacturers. The project identified future work of writing preliminary reports on current state-of-the-art of EV chargers including the inverter technology, embedded sensors, power rating, control capabilities, response time and on the literature search of transient overvoltage mitigation issues and methods at sub circuit level service area with high PV to load ratios. Reports will be prepared on the transient time domain model of a sub circuit service area that includes the model of EV charger and PV inverters and on potential solutions that EV chargers bring to mitigate transient overvoltage at sub circuit level.

SPECIALIZED ELECTRIC VEHICLE APPLICATIONS

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: A preliminary meeting with Florida Turnpike engineers concluded that the Florida Turnpike network would be used for this project. Research is being conducted to develop an average dynamic model of EV traffic flow passing through entrances/exits and a queuing model for each of the service stations. Their combination will allow the study of average waiting time of EVs at any given service station with respect to traffic flow rate and the number of chargers available. Following model development, the researchers will investigate the problems of designing of a distributed scheduling algorithm for optimizing the overall transportation network and a cooperative control for individual drivers to make their decisions.

14. Electric Vehicle Bus Systems

Objective: Model public electric bus transportation systems. The analysis will include route distance and timing, charging times, impact of type of chargers, maintenance and operational characteristics and economic comparison with diesel powered buses. The first project will be to analyze the City of Tallahassee's Star Metro electric bus fleet.

Accomplishments: The project is analyzing five all-electric buses operating in Tallahassee, FL. Tallahassee StarMetro Transit acquired five Proterra all-electric buses and installed a FastFill™ fast charging station in July, 2013. The initial buses cost \$ 1.5 M/bus but the price has since dropped to its present asking price of \$0.95 M/bus (a diesel bus cost roughly \$0.45M). Each electric bus is equipped with an 8-pack of 24V, 72 kWh batteries with a range of 30 miles per charge. These buses follow a 20 mile fixed route loop. The fast charger can automatically charge the buses without drivers' involvement in 6-7 minutes. The project identified future work of developing a MATLAB model to simulate and optimize the routes, stops, passenger pick-up and drop-off schedule, and charging of the electric buses of StarMetro. The economics (initial cost, operating costs, including electricity, maintenance and downtimes) of the electric buses will be analyzed and compared to that for a conventional diesel bus. Literature research will be conducted on electric bus technologies, charging stations, and operational experiences.

15. Vehicle to Grid Applications Using Electric School Buses

Objective: Evaluate the effectiveness of deploying electric school buses for vehicle-to-grid applications. For a selected application, the research is to analyze the interplay of route travel distances, battery usage and lifetimes, charge station requirements, inductive charging options, and provision of maximum value to electrical utilities.

Accomplishments: The first phase was spent conducting research on the manufacturers and customers who have invested in electric bus development, as well as research on ancillary services that may be provided through V2G installations.

16. Electric Vehicle Fleet Implications and Analysis

Objective: Evaluate the effectiveness of electrical vehicles use in fleet system operations. The focus of this work is to examine route travel distances, battery usage and lifetimes, charging station requirements and economics, as well as how fleet adoption will impact overall rate of market penetration of electric vehicles.

Accomplishments: Fleet outreach efforts revealed that public and private fleet transition to electric vehicles is limited by a number of factors, including incentives, procurement barriers, and infrastructure limitations. These results will form the basis of future market penetration research.

SOCIO-ECONOMIC IMPLICATIONS

17. Electric Vehicle Assessment and Societal Integration

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: The initial EV analysis has been completed based on recent Hawaii Natural Energy Institute (HNEI) and General Electric International, Inc. (GE) high fidelity dispatch modeling efforts, ("Oahu Electric Vehicle Charging Study", 2013). Renewable

energy base cases were modeled with 600 MW to 1000 MW of combined wind and solar photovoltaic capacity on the future Oahu grid, with a peak load of about 1200 MW. Grid-connected EVs were explored for their potential to take up the excess or “curtailed” energy when wind and solar resources exceeded the maximum that could be absorbed into the electricity grid system. Additional petroleum fuel for electricity generation (to balance intermittency of wind and solar) was quantified for each future scenario’s EV load.

Results showed that under the modeled future renewable energy base cases before EVs were added, 10 to 23 percent of the combined wind and solar energy were curtailed. It was expected that much of this curtailed energy could be captured by strategically charged EVs. With a very large fleet of EVs and assuming all EVs follow a practical, controlled charging profile, curtailed energy was reduced by 18 to 46 percent. Significant reductions in curtailed energy can be made with modification to Oahu’s grid.

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: An extensive literature review has been undertaken to identify current research gaps. Based on the identified gaps, research is currently investigating the impacts of regional driving patterns and electricity generation mix scenarios (marginal and average) on energy use and green-house gas (GHG) emissions of alternative vehicle technologies. The project identified future work of investigating how these spatial variations influence the vehicle technology preference at state level. Research will quantify the relative impacts of battery and vehicle manufacturing on GHG emissions and energy consumption within the total life cycle of vehicles, and to evaluate the impacts implications of alternative policy scenarios.

19. Economic Impacts of Electric Vehicle Adoption.

Objective: Project will examine likely levels of EV adoption in order to estimate the impact to the State of Hawaii’s economy, and to determine the level of opportunity in EV’s as a grid stabilization tool. Analysis will include the determination of a set of scenarios for EV adoption in Hawaii over time based on consumer vehicle preferences, identifying the impact of EV penetration to the electric sector in terms of electricity generation, costs and GHG emissions, and estimating the effect of EV adoption to the state economy in terms of impacts to gross state product, sector activity and household welfare.

Accomplishments: The first phase has been spent collecting literature on vehicle adoption rates and practices. Results include identification of several sources of Hawaii-specific vehicle fleet data, the beginning of data collection and the vetting of model assumptions. findings/assumptions that will help to form a series of EV adoption scenarios. These will be used as alternative scenarios within the economic analysis. To calibrate the economic model,

a comprehensive dataset of vehicle fleets in Hawaii will need to be developed which includes sensitivity analysis to vehicle adoption rates.

TECHNO-ECONOMIC SYSTEMS ANALYSIS

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 electricity grid.

Accomplishments: A four-year plan has been developed to subdivide the project into manageable milestones identified as: 1) identify an external partner and start the development of a scalable model of large-scale EV and power grid systems. Partner: Florida Turnpike Authority, 2) develop a scalable model of large-scale EV and power grid systems, with the attributes provided by external partners, 3) work on developing and optimizing both G2V charging and V2G feeding algorithms, and 4) working on optimizing both transportation network and electric power grid.

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: The first two quarters of the project were spent training graduate students on use of the SWITCH power system model and collecting data needed to model power system expansion. One work product was a database of finely resolved wind and solar data from two references. Techniques and data sources were developed for identifying locations for solar panels and wind turbines throughout Oahu. In addition, preliminary steps were taken toward building the roof area database and siting turbines: developing image processing techniques for building footprints from Google Maps images; screening out unsuitable locations for wind turbines based on land-use and terrain and developing algorithm for siting individual turbines within the allowed areas. The project identified future work of developing EV usage profiles to allow determination of benefits of optimally-timed EV charging, electric grid infrastructure requirements and costs, and duty cycles for batteries used in both G2V and V2G for battery degradation analysis.

Industry Collaboration Accomplishments

Industry collaboration efforts have been very aggressive for the first project period. Three meetings have been held with FPL, two meetings with NovaCharge Inc. (a Florida based electric vehicle charging company), a meeting with Tallahassee StarMetro bus authorities, a meeting

with Florida Turnpike Authority, and a meeting with three Florida Department of Transportation officials. In addition, EVTC staff members are part of Drive Electric Florida which is 43 member organization co-chaired by Britten Cleveland of the Sierra Club and Anne Louise Seabury of FPL. Drive Electric Florida members are from a variety of EV related organizations that include FPL, Duke Energy, Orlando Utilities Commission, NovaCharge, GM, Ford, Nissan, several Florida counties and the Clean Cities Coalitions that are currently active in Florida.

Education and Workforce Development Accomplishments

Tuskegee University has accomplished seamless integration of EVTC projects in the senior level Physics course curriculum in both Fall 2013 and Spring 2014 semesters. In the Fall 2013 semester, one minority female student, Ms. Leah Sanks, (Physics major) was successfully trained for the EVTC project and conducted research to explore the number of plug-in-hybrids and the number and types of electric vehicle charging stations in Alabama. The research results were part of her Physics 551 seminar course and Ms. Sanks presented her findings at the Society of Physics Students Colloquium in fall 2013. In spring 2014, the Tuskegee University PI, Dr. Sessa Srinivasan included the topic “Alternative Electric Vehicle” as part of the Modern Physics course PHYS 502, and 6 students successfully completed the course.

The EVTC has participated in the development of a two hour webinar that covers the basics of Electric Drive Vehicles. The webinar was a cooperative effort of the EVTC, the Central Florida Clean Cities Coalition and Jason Gaschel, an instructor certified by the National Alternative Fuel Training Consortium (NAFTC). The webinar is available on demand to Clean Cities and EVTC stakeholders and partners. It will also be used as a prerequisite for courses that are currently under design by the EVTC.

The research projects outlined above have seven students working on them. There are currently three Ph.D. students working on the socio-economic impact project, Nuri C. Onat, Mehdi Noori, and Tolga Ercan. The bus project has one electrical and computer science MS student, Wenjin Yang. The socio-economic project has one student, Ms. Sherilyn Wee, a Ph.D. student in the University of Hawaii, Department of Economics. And, Ms. Leah Sanks and Mr. John Scruggs have directly participated in the EVTC program at Tuskegee.

A workforce development plan is an integral component of the overall program. A review of knowledge, skills and abilities for practitioners in the PEV industry has provided a foundation for a database of requirements for entry into PEV careers. We have established a relationship with CareerSource Brevard, our local workforce agency, for the purpose of accessing their connections and programs in the workforce development area. In addition, the Central Florida Clean Cities Coalition is playing a major role in workforce development efforts using U.S Department of Energy approved curriculum for training of new and incumbent workers in alternative fuel vehicles.

Technology Transfer Accomplishments

The EVTC is participating in the Council of University Transportation Centers (CUTC). It is noted that UCF is a long standing, 20 year member of CUTC. The EVTC's objective of fostering the growth of new business development using the UCF incubator and Angel Network programs has established contact with Mr. Oscar Rodriguez who is the Director of Business Development

for UCF's College of Engineering and Computer Science. As the EVTC program develops, Mr. Rodriguez will be using the EVTC program's results in his business development efforts.

Diversity Accomplishments

STEM (Science Technology Engineering and Mathematics) education especially in minority, under privileged and underrepresented groups is in major crisis. This is because of lack of interest among students, lack of financial support and inadequate laboratory facilities. Tuskegee University in partnership with UCF/FSEC and the University of Hawaii will address the need for STEM based curriculum development, workforce training and outreach to foster and enhance the minority students' graduating in STEM with a focus on an "Electric Vehicle Transportation" concentration. The broader impact of creating the STEM platform for the minority students' via the EVTC will undoubtedly sustain and strengthen the 21st Century education and training STEM portfolio of the US. The outcome based on the objectives is to disseminate EVTC course curriculum (undergraduate and graduate level), hands-on training notes, peer reviewed journal publications, conference presentations and proceedings, and most importantly the minority students' population retention in STEM through their participation in the EVTC projects.

STEM activities also included the review of a report released in November 2013 by the National Center for Education Statistics of the U. S. Education Department. This report found that students from 2009 to 2013 taking STEM disciplines had a growth rate of 19.1% as compared to non-STEM disciplines at 8.7% and all disciplines at 11.8%. The report also listed the growth rates for students per STEM major as follows:

- Earth, atmospheric, and ocean sciences -- 39.4%
- Math and computer sciences -- 30.1%
- Engineering -- 23.8%
- Biological and agricultural sciences -- 22.7%
- Physical sciences -- 19.8%
- Psychology -- 19.0%
- Social Sciences -- 10.4%

Because of the diversity of the EVTC program, its activities can impact all of these majors.

Metrics

Performance metrics for the EVTC project are designed to drive improvement and characterize progress and effectiveness. Because the program is in its initial development stages no metrics have yet been applied. See Metrics section above for the framework of this future activity.

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

Training and professional development activities have been provided by Tuskegee University and its students and by the electric vehicle webinar (both of these have been previously presented in the Education and Workforce Development Accomplishment section).

How have the results been disseminated?

Two students (Leah Sanks and John Scruggs) developed, with their mentors, a poster which was presented at the UTC Southeastern Regional Conference held at Georgia Tech in March 2014. Based on the EVTC projects, these particular students with other Physics majors have successfully won a Sigma Pi Sigma Undergraduate Research Award and Marsh M. White Outreach Award from Society of Physics Students National Office in Washington DC. Ms. Leah Sanks was also nominated for the Tuskegee Presidents All-STAR Students' Recognition in fall 2013.

Ms. Sanks and Mr. Scruggs also presented their posters at the recently held Joint Annual Research Symposium, Tuskegee University (Feb. 2014) and Alabama Academy of Science 91st Annual Meeting, Auburn, University, AL (Mar. 2014).

Two other Outreach activities were conducted this spring 2014 by the Tuskegee University Principle Investigator (PI) and his undergraduate students. Dr. Srinivasan was invited to present his EVTC related demonstrations at the American Association of Physics Teachers Alabama Chapter meeting in Mobile, AL. The students and the PI were invited by the Principal of Booker T. Washington High School in Tuskegee, AL to show case the EVTC project and other Renewable Energy, Hydrogen Fuel Cell Technology demonstrations to high school students. Both events received high levels of recognition. The students and teachers appreciated this outreach and encouraged the PI to conduct future visits.

Presentations

1. Electric Vehicle Transportation Center at UCF, UH and Tuskegee
Presenters: Richard Raustad (UCF), Sessa S. Srinivasan (Tuskegee)
2. Alternative Electric Vehicles. Sessa S. Srinivasan, David L. Block, Prakash C. Sharma.
Presenter: Leah Sanks (Tuskegee)

Publications

1. Block, D., & Harrison, J. (January 2014). "Electric Vehicle Sales and Future Projections", EVTC Report Number EVTC-RR-01-14. Cocoa, FL: Florida Solar Energy Center.
2. Qin, N., Brooker, P., & Srinivasan, S. (March 2014). "Hydrogen Fueling Station Infrastructure", EVTC Report Number EVTC-RR-02-14. Cocoa, FL: Florida Solar Energy Center.

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

The program for the past six months has concentrated on developing the EVTC program and assigning staff and students to the EVTC projects. These 21 projects are presented in the Accomplishments Section. The next six months will see the research activities begin in all of these projects. Evaluation will follow each of the activities. It is also noted that in the 21 projects accomplishments many of them have stated their future activities.

With regard to program goals, clearly-defined milestones and deliverables have been established. The EVTC management plan requires quarterly reporting from each partner institution throughout the entire program effort. Adherence to these criteria will be strictly enforced and will be used to monitor and manage project performance.

Tuskegee is planning to work with Alabama Power and the Alabama Department of Transportation (AL-DOT) to enhance the STEM curriculum, education and research training based on EVTC in the coming academic year (Fall 2014-Spring 2015). Basic and applied research at the undergraduate level will be conducted in the summer 2014 and 2015 semesters.

II. Products

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

1. EVTC web site: The EVTC web site was developed to provide researchers and interested parties detailed information on this project. The site includes a listing of the current research projects being conducted as well as educational information, technology transfer, news and events, publications, and resources applicable to the overall EVTC project. The site can be accessed at <http://evtc.fsec.ucf.edu/index.htm>.
2. Transportation Research Board of the National Academies Research in Progress (RiP) Database submissions: Project inputs were made to the RiP data base for twenty-two projects. This included the overall EVTC project as well as the twenty-one specific research projects. The projects are now available on the RiP database for interested parties.
3. Four EVTC personnel attended the University Transportation Center (UTC) Conference for the Southeastern Region at Georgia Tech Global Learning Center on March 24 and 25, 2014. In addition to the introductory presentation provided at the beginning of the conference, a more detailed overview of the EVTC was presented to participating UTC representatives. A poster session, presented by Tuskegee University, provided information on electric vehicles and electric vehicle supply equipment.
4. A final project research report was developed on Project #5, Electric Vehicle Sales and Future Projections: The report has been posted to the respective Project RiP entry and also on the EVTC web site. The report can be accessed at <http://evtc.fsec.ucf.edu/publications/index.html>.
5. A semi-annual project report on Project 10, Hydrogen Fueling Station Infrastructure, has been completed. The report can be accessed at <http://evtc.fsec.ucf.edu/publications/index.html>.
6. An electric vehicle webinar has been developed by both the EVTC and Clean Cities programs. The webinar is completed, is two hours in length and covers the topics of environmental effects, hybrid vehicles, alternative fuel vehicles and electric vehicles (http://www.fsec.ucf.edu/en/education/cont_ed/brevardwf/index.htm).

III. Participants & Collaborating Organizations

What organizations have been involved as partners?

The three universities of the EVTC are:

1. University of Central Florida --The lead for the EVTC is the University of Central Florida (UCF) which is the second largest university in the nation by enrollment. The three active participants within UCF are:

- Florida Solar Energy Center (FSEC) -- FSEC is Florida's energy research and education institute, and it is the largest and most active state-supported renewable energy and energy efficiency research organization in the U.S. FSEC's programs are nationally and internationally recognized. FSEC also has the distinction of serving as the Coordinator of the U.S. DOE-funded Central Florida Clean Cities Coalition since 1997. Activities include facilitating the adoption of alternative fuel vehicles (AFVs); assisting in the development of AFV infrastructure; conducting public education and outreach programs; organizing and hosting stakeholder meetings and events; and, providing technical assistance and special training to early adopters of AFVs.
- Civil, Environmental and Construction Engineering--UCF's Civil and Environmental Engineering Department is a subcontractor to the DOT National Center for Transportation System Performance and Management, a Tier 1 University Transportation Center, led by the Georgia Institute of Technology. The UCF Center-related activities involve modeling and computer simulations and K-12 education and STEM initiatives that are conducted in cooperation with the College of Engineering Diversity Office.
- Electrical and Computer Engineering--UCF's Electrical Engineering and Computer Science Department has a national reputation in autonomous vehicle technology and has developed successful R&D collaborations with Lockheed Martin, SAIC, L-3 Communication, and United Technologies Corp.

2. University of Hawai'i at Manoa -- The University of Hawai'i at Manoa (UH) is the flagship campus of the University of Hawai'i System. Within UH Manoa, the Hawai'i Natural Energy Institute (HNEI) is an organized research unit that performs research, conducts testing and evaluation, and manages public-private partnerships across a broad range of renewable and enabling technologies to reduce the State of Hawai'i's dependence on fossil fuel. HNEI conducts research in the areas of alternative fuels; renewable power generation technologies; energy efficiency; electrochemical power systems; and systems integration/energy security. HNEI has tenure track and non-tenure track faculty, allowing substantial flexibility in realigning research efforts with current state and national priorities.

3. Tuskegee University -- Tuskegee University is a national, independent, and state-related institution of higher learning. Tuskegee University's entities involved in the EVTC program are the Department of Physics and College of Engineering. Physics programs include electric and alternative fuel vehicle transportation, renewable energy, hydrogen storage, photocatalysis, nanotechnology, biomedical research, computation and modeling, density functional theory,

solid-state theory, pedagogic research and education. Tuskegee University will also receive support from its Alabama Clean Fuels Coalition (ACFC).

What organizations have been involved as collaborative partners?

Industry collaboration efforts have centered on establishing partnerships in areas that have EVTC related projects. These projects and the collaborative partners are:

1. Identify and Analyze Policies that Impact the Acceleration of Electric Vehicle Adoption (Project 2)

This project will work with Drive Electric Florida which is 43 member organization co-chaired by Britten Cleveland of the Sierra Club and Anne Louise Seabury of Florida Power and Light. Members are from a variety of EV related organizations that include FPL, Duke Energy, Orlando Utilities Commission, NovaCharge, GM, Ford, Nissan, several Florida counties and the Florida Clean Cities Coalitions.

2. Electric Vehicle Charging Technologies and Analysis (Project 3)

Partners are: Helda Rodriguez, President, NovaCharge Inc.

3. Battery Technologies for Mass Deployment of Electric Vehicles (Project 8)

Tony Markel, National Renewable Energy Laboratory

4. Electric Vehicle Grid Experiments and Analysis (Project 10)

Ken Srebnik, Russell Vare, Nissan-USA, and Tony Markel, National Renewable Energy Laboratory

5. Optimal Charging Scheduler for Electric Vehicles on the Florida Turnpike (Project 13)

– Florida Turnpike Authority. Partners are: Thomas Wilke, Manager, Environmental Management Office, Florida Turnpike Headquarters

6. Electric Vehicle Bus Systems (Project 14) – Tallahassee StarMetro Bus Authorities –

Partners are: Ralph Wilder, StarMetro Transit Agency, Tallahassee, FL, Steve Clermont, Project Management, Technical Assistance, Data Collection and Analysis Center for Transportation and the Environment (CTE), Atlanta, GA, Leslie Eudy, Hydrogen Technologies and Systems Center, Hydrogen Technology Validation, National Renewable Energy Laboratory

7. Develop EVTC Partnerships with Industry, Utilities, and Governmental Agencies (Project 23) –

Meeting with three Florida Department of Transportation officials. Tom Percival Jr., Manager, Environmental Management Office Florida Turnpike Headquarters, Daryll Dockstader, Research Program Coordinator, Florida Department of Transportation, Robert McDaniel, SunRail Public Transportation Specialist, George A. Hutchinson, Senior Director, Power and Energy Solutions, Concurrent Technologies Corporation

8. **Tech Transfer to Foster Business Development using UCF Incubation Program and Angel Network (Project 24)** – Meeting with UCF Rosen College of Hospitality Management, Robertico Croes, Professor & Chair, Rosen College of Hospitality Management, UCF, Jill Fjelstul, Associate Professor, Rosen College of Hospitality Management, UCF, Alan Fyall, Orange County Endowed Professor of Tourism Marketing, Rosen College of Hospitality Management, UCF

9. **Technology Transfer and Research -- U.S. DOE-funded Central Florida Clean Cities Coalition** – UCF/FSEC has served as the Coordinator of the U.S. DOE-funded Central Florida Clean Cities Coalition since 1997. The Clean Cities Coalition represents 35 alternative fuels related organizations and its activities include facilitating the adoption of alternative fuel vehicles (AFVs); assisting in the development of AFV infrastructure; conducting public education and outreach programs; organizing and hosting stakeholder meetings and events; and, providing technical assistance and special training to early adopters of AFVs.

IV. Changes/Impact

Although not yet implemented, an important impact of the emerging battery technology task will be the development of two websites that enhance the ability of researchers to obtain information regarding the state-of-the-art in battery chemistries. To this end, a battery chemistry website is planned that will follow the model of Hydpark, a DOE website that has collected information on metal-hydride storage over the past several years (see <http://www.hydrogenmaterialssearch.govtools.us/>). The battery chemistry website will focus on the various components of batteries and the current research in the field, summarizing their performance metrics and limitations. A second effort for information dissemination is to compile information regarding safety standards for li-ion batteries into a single website.

V. Changes/Problems

There are no changes or anticipated problems in the EVTC developed programs.

VI. Special Reporting Requirements

The following table presents a listing of the EVTC projects with the responsible university and principle investigator. The table also includes the other associated activities such as education, STEM, etc.

Ongoing EVTC-Funded Research Projects		
Project Title	Lead University	Principal Investigator
Implications of Electric Vehicle Penetration on Federal and State Highway Revenues	UCF	Kevin Schleith
Identify and Analyze Policies that Impact the Acceleration of Electric Vehicle Adoption	UCF	Colleen Kettles

Electric Vehicle Charging Technologies and Analysis	UCF	Richard Raustad
Electric Vehicle and Infrastructure Safety Requirements and Regulations	UCF	Colleen Kettles
Prediction of Electric Vehicle Penetration	UCF	David Block
Electric Vehicle Life Cycle Cost Analysis	UCF	Richard Raustad
Assess the SunGuide® and STEWARD Databases	UCF	Richard Raustad
Battery Technologies for Mass Deployment of Electric Vehicles	UCF	Paul Brooker
Electric Vehicle Battery Durability and Reliability under Electric Utility Grid Operations	UH	Matthieu Dubarry
Fuel Cell Vehicle Technologies, Infrastructure and Requirements	UCF	Nan Qin
Electric Vehicle Grid Experiments and Analysis	UCF	Richard Raustad
Electric Vehicle Interaction at the Electrical Circuit Level	UH	Reza Ghorbani
Optimal Charging Scheduler for Electric Vehicles on the Florida Turnpike	UCF	Zhihua Qu
Electric Vehicle Bus Systems	UCF	Ali Raissi
Vehicle to Grid Applications Using Electric School Buses	UCF	David Click
Electric Vehicle Fleet Implications and Analysis	UCF	Colleen Kettles
Electric Vehicle Assessment and Societal Integration	UH	Katherine McKenzie
Socio-economic Implications of Large-Scale Electric Vehicle Systems	UCF	Omer Tatari
Economic Impacts of Electric Vehicle Adoption	UH	Makena Coffman
Techno-Economic Analyses of Large-Scale Electric Vehicle Systems	UCF	Zhihua Qu
Effect of Electric Vehicles on Power System Expansion and Operation	UH	Matthius Fripp
ON GOING EVTC Non-research Projects		
Develop Electric Vehicle Workforce Statistics and Training Needs	UCF	Colleen Kettles
Develop EVTC Partnerships with Industry, Utilities, and Governmental Agencies	UCF	James Fenton
Tech Transfer to Foster Business Development using UCF Incubation Program and Angel Network	UCF	David Block
Education and Training of Scientists and Engineers by Partner Institutions	UCF	Zhihua Qu
Other Educational Activities: Short Courses, K-12 Education, Minority and STEM Education	UCF	David Block
Electric Vehicle Program as Applied to Minority and STEM Students	TU	Sesha Srinivasan