FESC
Florida Energy Systems Consortium

Florida Energy Systems Consortium Annual Report to the Office of the Governor Office of the President of the Senate Office of the Speaker of the House of Representatives Department of Agriculture and Consumer Services Florida Office of Energy Pursuant to Florida Statute 1004.648

Reporting Period: October 1, 2014 – September 30, 2015

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EXECUTIVE SUMMARY

Overview:
The Florida Energy Systems Consortium administration office worked very closely with the Office of Energy, the FESC Oversight Board, the FESC Steering Committee, and the FESC Industrial Advisory Board to request new recurring research funding from the state. The FESC administration office had several meetings/telecons with the Office of Energy during this reporting period to discuss the budget request and elucidate its positive impacts on the future of our state in the energy area. In addition, FESC administration met several representatives, senators, and staff members to lobby the FESC legislative budget request. FESC Industrial Advisory Board members signed a letter of support that was emailed to the key legislators in support of FESC funding request. All 12 University Vice President of Research (VPRs) were in support of this funding request; however we did not get the requested funds during this legislative session. The commissioner Putnam approved the same amount ($2.5M) for the next legislative session. We have a support letter from the FESC Advisory Board members, FESC VPRs, FESC Steering Committee members, and over 20 industry members in support of our legislative funding request. We are working with the Office of Energy and our Industrial Advisory Board to meet the key state representatives in support of our legislative request.

FESC Director Dr. Jennifer Curtis, accepted the position of Dean of Engineering at UC-Davis and she left the University of Florida effective October 2, 2015. Dr. David Norton, VPR, UF, tried to identify a suitable candidate to assume the role of FESC Director in collaboration with Dr. Jennifer Curtis prior to her departure; however a candidate who will fully recognize the SUS-wide mission of this Consortium couldn't be identified. Dr. Norton will be the Interim Director until a suitable candidate is found. All the VPR's are in agreement with this decision.

FESC continues to produce results in energy research, technology transfer, education, and outreach activities. The FESC administrative office is successfully facilitating interactions among Florida's energy industry and researchers at FESC universities, Florida's State and Community Colleges, and the Florida Institute of Technology. The FESC office has developed over 1000 faculty/industry contacts. This comprehensive network enables and facilitates the transfer of FESC technologies quickly for maximum benefit to Florida's economy. FESC coordinates research teams to develop and submit a significant number of joint proposals. FESC continues to contribute to energy education and outreach programs. FESC has 11 active projects. The list of these projects is given on page 14 of this report. Eight of these projects are in energy education area. The descriptions and brief progress reports of education projects are given in the "education" section of this report on page 23. The list of all FESC funded projects is given in Appendix A of this report. FESC provided new funding to the FESC Outreach team to continue with their Sustainable FloridianSM Program. During this reporting period, in addition to the development of the Sustainable FloridianSM Program, 41 fact sheets were updated from their prior versions and 16 new fact sheets were added. All the fact sheets were posted at the FESC web site and also at FDACS' My Florida Home Energy site. The outreach report is given on page 42 of this report.

The Florida Energy Systems Consortium continues to leverage State funding in energy research, technology transfer, education, and outreach activities. The FESC office facilitates submission of competitive proposals in a variety of ways - by disseminating solicitations, identifying research leaders and building teams to compete in these solicitations, communicating with industry partners, national labs and other non-SUS universities.

The FESC technology transfer program includes business plan/market research development (Phase I) and industry matched funding of early stage development (Phase II). **Thirty two (32) companies have been**

formed since 2008 based on university developed technologies. The company list with the area of technology is given in Appendix B.

FESC organized two workshops during this reporting period. The first one was about "Integration of Renewable Energy into the Grid". It was held at the Hyatt Regency Orlando Hotel in Orlando, FL on Feb 2-3, 2015. This instructional workshop was designed for industrial personnel, students and faculty who wanted to learn the state of the art and future directions in enabling renewable energy integration. A total of 114 people were in attendance; 66 university faculty and students, and 48 industry members. Experts in this area presented the workshop lectures.

The second one was FESC Annual Workshop that was held on May 20-21, 2015 at the Orlando Airport Marriott Lakeside in Orlando FL. Over 160 people attended. The workshop brought together energy experts in the State University System of Florida and industry to share their energy-related research findings and to promote future collaboration. The program featured internationally renowned speakers, as well as presentations and posters highlighting FESC's innovative work leading to alternative energy strategies, improved energy efficiencies and expanded economic development for Florida.

Three new industrial advisory board members joined the FESC board. The new members are: Thomas (TJ) Szelistowski, Managing Director – Regulatory Affairs, Tampa Electric Company, replacing Greg Ramon who passed away, Paul Zambo, Siemens, replacing Frank Bevc who retired from Siemens, and Bryan Levy, President and CEO of XChanger Companies Inc.

FESC Office established the "***Energy Crop Certification***" faculty workgroup in collaboration with Treasure Coast Research Park to develop a roadmap for a statewide implementation of an Advanced Biofuel Feedstock Certification Program. The primary goal of this program is to make alternate crops available for the farmers that have unusable land due to citrus greening issue. A new USDA grant was received by the team in support of this work.

FESC administration attended 21 conferences and workshops to expand the FESC network by developing new partnerships. The list of the conferences and workshops attended during the reporting period is given on page 19 of this report.

FESC prepares and distributes bi-monthly electronic newsletters by email to over 1000 subscribers. The e-newsletters are published at FESC website: http://www.floridaenergy.ufl.edu/?page_id=1999.

The Florida Energy Systems Consortium has made significant progress in its research, education, industrial collaboration, and technology commercialization agenda. FESC faculty members statewide are successfully collaborating in research and proposal development.

Research Highlights

The initial FESC research funds were dedicated to seeding energy research at five of the FESC universities with over 80 projects. A brief description of each completed and continuing research project is provided in Appendix A of this report. The projects are also posted at the FESC website http://www.floridaenergy.ufl.edu/?page_id=6 . The majority of the projects have been completed. There are 11 active FESC funded projects during this reporting period (listed on page 14 of this report). The project reports are given on pages 23, 42, and 93 of this report.

FESC Office established an "***Energy Crop Certification***" faculty workgroup in collaboration with Treasure Coast Research Park to develop a roadmap for a statewide implementation of Advanced Biofuel Feedstock Certification Program. The primary goal of this program is to make alternate crops available for the farmers that have unusable land due to citrus greening issue. The development of new hybrids, new cultivation methods and processing technologies of Advanced BioFuel (ABF) and Advanced BioChem (ABC) crops hold

tremendous promise but face substantial regulatory, technological and cultural barriers that prevent supply chain adoption. Energy Crop Certifications are handled by EPA; however due to demand, getting an approval takes a very long time. Roadmap development is needed in our state to streamline the EPA requirements to speed up the energy crop certification process. The faculty working group, in collaboration with Treasure Coast Research Park and State Office of Energy, will develop a "Workflow Process and Implementation Plan" for a statewide Advanced Biofuel Feedstock Certification Program. The team members had a telecon with the EPA official during this reporting period. Dr. Gary Peter and Dr. John Erickson are working collaboratively to develop the road map. FESC is one of the partners along with some of the FL farmers in USDA grant lead by the Treasure Coast Education, Research, and Development Authority (TCERDA). The aim is to perform feasibility study to determine the economic and environmental viability of expansion of the alternative biofuels supply chain in South Florida. This research will investigate the sustainable economic and environmental viability of cultivation and processing of industrial sugar and starch row crops including beets, tubers, sweet sorghum and cane to produce bio-jet fuel, bio-ethanol, bio-diesel fuel, bio-heating oil.

During this reporting period, FESC distributed and posted over **138 announcements of funding opportunities** with the goal of generating competitive SUS-based proposals and thus leveraging state funds. Several examples of collaborative proposal development are listed in the "New Program Development" section of this report. Appendix C contains the list of funding opportunities shared with FESC faculty and industry members.

Technology Commercialization and Industrial Collaboration

The consortium connects Florida's energy industry to statewide faculty members in order to meet the energy industry's technical needs and facilitates the commercialization of university energy-related technology. FESC is currently in communication with over 200 companies to provide technical assistance, to write collaborative proposals, or to assist Florida industry with university user facilities and faculty introductions in the expertise area needed. FESC office also works closely with technology transfer and economic development offices in Florida to attract industry to the state of Florida. The list of industry collaboration examples are given on page 21 of this report.

Thirty two (32) companies have been formed since 2008. The company list along with the technology area is provided in Appendix B. The technology of these companies is university-developed in areas that include solar fuels, concentrated solar, energy efficient optoelectronic devices, fuel cells, coating for battery/fuel cell, efficient light emitters, energy efficiency, bioenergy, and chemicals from biomass, nanoparticle thin film PV, waste to energy, and H_2 sensor.

FESC is continuing to promote and forge collaborations among energy experts across Florida's universities, Florida industry, and other Florida state entities to expand the comprehensive FESC network.

Education

FESC education program has three focus areas: 1- Community College program at the Associate of Science and certificate level run by FLATE; 2- Nuclear energy education; 3- Undergraduate/Master program. Progress highlights are given below.

Florida Advanced Technological Education (FLATE): Together with the National Science Foundation-funded Energy Systems Technology Technicians (EST^2) project team, FLATE has developed a new Industrial Energy Efficiency (IEET) specialization for the Engineering Technology (ET) Degree and associated College Credit Certificate, in addition to the existing Alternative Energy Specialization. The IEET program framework has been approved by the FL Department of Education and colleges will be able to implement it in the 2014-2015 academic year. FLATE's progress report is given on page 23 of this report. FLATE program had to be terminated due to lack of funds.

Undergraduate/Master and Certificate program: FESC has eight energy education projects to develop undergraduate/master-level courses. These courses will also be available on-line. The progress reports of these projects are given on page 25 of this report.

Outreach

FESC Outreach Team: The outreach team was provided funding to continue with the Sustainable Floridian[SM] Program. The mission of the Sustainable Floridian[SM] program is to guide Floridians on how to take individual responsibility for protecting Earth's limited resources. Through a discussion-to-action format, the program educates participants about making wise use of resources, making households and communities more resilient and financially sound, and understanding the impact of individual lifestyle choices. The Sustainable Floridian[SM] program report is given on page 42 of this report. The outreach team updated 41 fact sheets from their prior versions and developed 16 new fact sheets. All the fact sheets were posted at the FESC web site and also at FDACS' My Florida Home Energy site.

FESC Website and e-Newsletter: The FESC website continues to be an important communication tool for our program. It is updated regularly to remain current and to better serve our users. Based on a Google Analytics report, the FESC web site was viewed by 12,652 Google visitors during the period of October 1, 2014 through September 30, 2015. The viewers visited 43,338 pages. Viewers were from over 131 countries, including those in North and South America, Europe, Asia, Australia, the Middle East and Africa.

FESC prepares and distributes bi-monthly electronic newsletters by email to over 1000 subscribers. The e-newsletters are published at FESC website: http://www.floridaenergy.ufl.edu/?page_id=1999.

Other

- Working with the Gainesville Chamber to attract RES PolyFlow to Gainesville. RES Polyflow employs a patented technology to convert mixed and dirty plastic waste into transportation fuels and heating oils. Their technology utilizes plastic, the most energy abundant waste product representing 30% of the space in landfills. RES Polyflow (Akron OH based) operates and licenses the technology for use converting polymer waste into valuable fuels all around the world.
- Designed new FESC brochure and used these brochures for FESC legislative funding request lobby effort.
- Designed two FESC banners to be used at the Gator Day and at the FESC workshop.
- Collaborated with IBM and offered a professional development course at the University of Florida.
- Assisting other organizations/event by posting their conference information at FESC site.
- Provided support to FISE director to develop their web site. FISE web site can be viewed at http://fise.institute.ufl.edu/.

In summary, the Florida Energy Systems Consortium has made significant progress in its research, education, industrial collaboration, and technology commercialization agenda. FESC faculty members statewide are successfully collaborating in research and proposal development. FESC education programs are being readied for Florida's clean energy workforce, and our industry partners are actively participating in technology transfer and commercialization of FESC-developed technologies.

RESEARCH THRUST AREAS

Per Commissioner Putnam's request and feedback from the Office of Energy, FESC steering Committee members worked with FESC faculty and redefined the FESC research program goals with five focus areas. The details of the program are given below.

Five Focus Areas towards Florida's Energy Leadership

Five focus areas for the Florida Energy Systems Consortium (FESC) are summarized below. In each of these areas, Florida's state universities will partner with industry to provide technical expertise to meet pressing industry needs and to bring emerging energy technologies to market. These novel technologies harness Florida's natural resources and reduce energy dependency on outside sources. In addition, these focus areas will be represented in the consortium's workforce development programs which serve Florida's utilities and in the consortium's education programs which serve the public by reducing their energy bills through conservation.

Supporting Utilities in Smart Grid and Energy Storage

Support Investor Owned Utilities (IOU), Cooperative Electric Utilities, and Municipal Utilities to develop smart grids with intermittent power sources such as PV and wind, distributed electric generation, state-of-the-art power electronics, and grid level energy storage.

Enhancing Energy Efficiency and Conservation

Develop new technologies for high efficiency HVAC building retrofits using advanced sensing and control; conduct field evaluations to document the cost/benefits of building energy efficiency programs; develop solutions to help absorb intermittency of renewable energy sources by using fast-responding management of building loads such as HVAC; and recruit advanced Florida builders and early adopter homeowners to collaborate on zero energy building design and retrofit projects.

Converting Florida's Biomass to Renewable Fuels

Develop energy-rich crops to supplement agricultural residues as sources of cellulosic biomass; develop scalable and cost-effective processes to produce fuels, chemicals, and power from biomass and algae; develop cost-effective integrated anaerobic digestion systems to support Florida's farmers in producing bioenergy (methane) and bio fertilizer from Florida feed stocks.

Harnessing Florida's Solar Energy

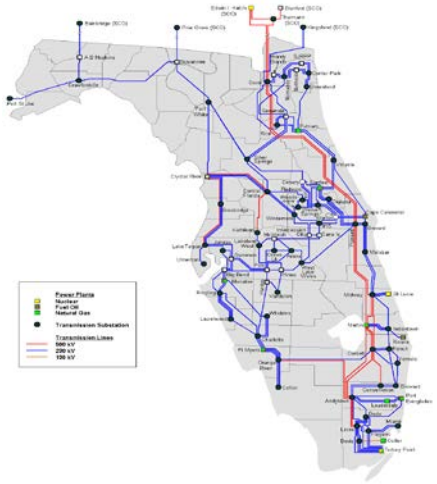
Improve solar PV panel efficiency; work towards automatic permitting, automatic utility interconnection, and autonomous operation of PV systems; develop high-temperature, thermal energy storage for concentrated solar power technology; develop transportation fuels with solar energy by converting water and CO_2 to syngas then liquid fuels; develop solar desalination technology.

Power Generation by Using Marine Hydrokinetic (MHK) Resources

Develop technologies to harness ocean current energy, ocean wave energy, and ocean thermal energy to produce electricity; determine whether offshore wind is a viable renewable energy resource for Florida and whether it is capable of supporting a new industry and the jobs and revenue that could come with it; assist a growing ocean current energy sector to identify and reduce various barriers to commercial implementation.

Detailed Descriptions of the Focus Areas

Supporting Utilities in Smart Grid and Energy Storage



According to a reliable 2008 study by the Political Economy Research Institute, an investment of $8 Billion in Florida's electric infrastructure would result in 123,756 persistent Florida jobs. In 2011, Florida consumed over 230 terawatt-hours of electricity, or the equivalent of about $25 billion in retail sales. It was second in the nation in electric energy consumption behind Texas. These recommended investments and this staggering level of load are a unique Florida opportunity, an opportunity that is often referred to as smart grid investments or grid modernization. The investments will provide better jobs, reliability, flexibility, information and automation - all of which are essential to growing Florida's economy.

Florida Power and Light's (FPL's) smart grid expansion is costing over $800 million. FPL has achieved real economic, safety, and reliability benefits from a fully wired and operational smart grid. FPL has shown that when done correctly, a smart grid is able to automatically sense and gather important data about both consumer and supplier habits, allowing operators and computers to better tweak systems before any major problems arise. FPL installed 4.5 million smart meters alongside more than 10,000 sensors all over the grid. To date, over four hundred malfunctioning transformers have been sensed before they caused a power outage, probably saving Florida small and large business tens of millions, if not over a hundred million dollars in lost revenue. Duke Energy, Gulf Power, TECO, JEA and a host of municipal and cooperative utilities are just as engaged.

FESC universities actively collaborate with Florida utilities in high profile projects. The Gateway to Power Consortium (G2P), led by FPL and Smart Energy Grid Associates, seeks to deliver workforce training for electrical power sector personnel in areas most relevant to the next-generation electric power workforce. The $3.6M US DOE funded SUNGRIN initiative is looking at the implications of a high penetration of solar energy on the Florida Grid. The FESC initiated Network of Energy Sustainable Communities (NESC) provides information and venues to train the local government units on energy opportunities, increasing their efficiency in capturing federal energy block grants. Florida's $126 Million US DOE funded SunSmart program has worked to increase the deployment of solar energy and energy storage systems in schools, business and electric vehicles. The following are some of the areas to focus:

1. **Floridian Economics, Policy Uncertainty and Consumer Behavior:** We must know, in order of magnitude, the energy economy investments that yield the greatest benefit to utilities, consumers, energy security and energy independence.
2. **Science and Technology to Support Florida's Generation Capacity Growth, Transmission Grid Expansion, Efficiency and Modernization:** FESC must determine the right priority of investments that need to be made in electric generation (in particular the mix of new nuclear, clean coal technologies that pass new US EPA standards, natural gas, and alternative sources), as well as identify the transmission upgrades that will lead to higher distribution availability (new and self-healing lines) and efficiency.
3. **Science and Technology to Support Florida's Distribution Grids, Distributed Generation Resources, Demand Side Management, and Premise Appliance integration in Efficiency Programs:** We must first educate a changed and enlightened consumer (conservation). Additionally, automating efficiency and load management functions will allow Florida to do more with less electricity, provide grid stabilizing ancillary service and lessen the need for expensive and dirty fast ramping electric generation.
4. **Resilient Grids by Using Science and Technologies of Cyber-Physical Systems**: Advanced metering implementation has meant unprecedented access to data through distributed sensors. To obtain access to all of this data requires communication infrastructure, and to make use of this data requires a combination

of automated centralized and decentralized decision making (e.g. fault detection and response). Advanced monitoring, detection, protection and controls must be developed and implemented that reliably meet the needs of the grid. These technologies must be robust to hardware failures and resilient to malicious attacks.

5. **Electric Vehicles (EV) as a Solution to Florida's Significant Energy Storage Problem:** Much of the promise of Smart Grid is based on a perception that it will lead to an increased penetration of renewable energy. Unfortunately, this may never come to pass in Florida if man-made energy storage options do not become available. Florida has almost no opportunities for natural energy storage at grid-scale. Because EV are a significant leveraging factor, Florida may be the best state in the country to first achieve a true economic electric vehicle based transportation economy.

Enhancing Energy Efficiency and Conservation

Energy efficiency and conservation offer the greatest potential to reduce Florida's energy consumption. Buildings use more energy than any other sector of the economy, including transportation and industry. Therefore, the focus of this thrust area is on improving resource efficiency in the built environment: including existing and newly constructed residential and commercial buildings both at the scale of individual structures and communities. Because of Florida's hot/humid climate, much of the building sciences research conducted nationally doesn't apply well in our state. Building performance research is needed to evaluate and support implementation of specific efficiency practices in Florida. Key research opportunities include development of novel energy efficiency retrofit technologies and analysis of end-use energy consumption data in collaboration with utilities. The following are some of the areas to focus:

1. Energy Efficient Building Technologies for Residential and Commercial Buildings: Buildings account for ~84% of total electric power use in the state. A 35% reduction in building energy use can be achieved by improved efficiency, saving Florida millions of kWhr/yr. Further reduction can be achieved by creating "zero energy homes" using only on-site PV power, a stated goal of the U.S. DOE. This offers the opportunity to develop marketable products that meet Florida's energy and environmental goals. New and emerging building energy efficiency systems require study with respect to Florida's unique hot/humid climate. Cost/benefit analysis of efficient buildings, building energy efficiency expertise in our education system and our marketplace along with creative financial instruments and business models are needed. Conservation can also benefit from the use of more renewable energy sources. New technologies are needed to handle the intermittent nature of renewables. Buildings are expected to play a key role since they form the largest electric demand. To address this need, FESC will develop new technologies for high efficiency HVAC retrofits in both commercial and residential buildings using advanced sensing and control, conduct field evaluations to document the cost/benefits of "beyond code" building energy efficiency programs; conduct testing of building efficiency options; create building energy course work; construct and monitor zero energy buildings; develop solutions to help absorb intermittency of renewable energy sources by using fast-responding management of building loads such as HVAC, including benefit/cost analysis and their effect on the electric grid; and recruit advanced Florida builders and early adopter homeowners to collaborate on zero energy building design and retrofit projects. As part of the Consortium, well-instrumented testing structures and buildings will be established to evaluate the effectiveness of integrated emerging technologies.

2. Analysis of Metered Energy Consumption Data to Increase Effectiveness of Florida Utilities' Demand Side Management (DSM) Programs: Florida utilities have made substantial investments in energy conservation and efficiency programs. Expectations of savings, or deemed savings, are typically used to estimate program cost effectiveness and make decisions about DSM portfolios, types of programs, and specific energy conservation measures. Although metered consumption data are readily available, utilities seldom conduct follow-up evaluations of savings. Systematic measurement and verification (M&V) is

needed to accurately determine whether utility DSM programs are actually achieving their energy and demand savings goals. FESC proposes to evaluate end-use energy consumption data from Florida municipal utilities merged with property appraiser and DSM program data for the following research and analysis tasks: measure energy savings of high-efficiency HVAC DSM participants; establish marginal energy savings values across equipment efficiency levels (SEER-14 to SEER-18 vs. SEER-13); compare measured to modeled/deemed savings estimates; calculate the individual and average cost effectiveness of high-efficiency HVAC retrofits; identify poor performers among installed HVAC systems from data, and flag for maintenance and/or re-commissioning; and provide results to partnering municipal utilities for targeting of future DSM programs to the customers likely to achieve the greatest savings.

Converting Florida's Biomass to Renewable Fuels

FESC member universities are internationally recognized leaders in biomass energy research. Florida ranks first in the country in annual generation of cellulosic biomass with almost 10% of the US total. In Florida several biomass species are produced in large volumes, primarily sugar cane bagasse in South Florida, citrus peel in Central Florida, and woody biomass in North Florida. Moreover, the State has all the key assets for algae technologies: year-round warm weather and sunlight, long shore line, under-utilized land (decommissioned phosphate mines and aquaculture operations), CO_2 from Florida industries (utility, cement, mining, landfills), and wastewater from industrial and municipal treatment facilities. Harnessing cellulosic biomass and algae for conversion to liquid transportation fuels (and other value-added products) is a huge economic opportunity, as over 135 billion gallons of gasoline (worth over $400 billion) and 60 billion gallons of aviation, military, and diesel fuels (worth over $200 billion) are consumed annually just in the United States. Florida's location and resources position it to be a leader in the development and commercialization of biomass-to-fuel technologies in partnership with the private sector. Such a leadership will bring investment, jobs, and tax revenue to the State and will diversify Florida's economy, while making it more sustainable. We propose four (4) key focus areas:

1. **Feedstock Development and Deployment:** With our expertise in genetics and management, we will develop energy-rich crops to supplement agricultural residues as sources of cellulosic biomass. Using breeding and molecular genetics we will develop high energy-yielding cultivars with improved biosafety and by employing management science we will devise growing systems for Florida annual and perennial grasses, oil- and sugar-rich plants, and woody and aquatic energy crops. In parallel, we will develop economic models to estimate costs and identify opportunities for farmers and investors.
2. **Cellulosic Biomass Technologies:** Using our expertise in applied biomass research we will develop scalable and cost-effective processes to produce fuels, chemicals, and power from cellulosic biomass. In the biochemical approach we will study pretreatment and enzymatic hydrolysis to convert biomass to sugars for microbial fermentation to biofuels and hydrocarbons. In the thermochemical approach gasification and catalytic conversion or pyrolysis will convert biomass to drop-in liquid hydrocarbons, power, and co-products such as fertilizers. The technical data will be fed to economic models to calculate capital and operating costs and required key resources (energy, water, raw materials, and land).
3. **Algae Technologies:** Based on our expertise in algae research we will develop modular and cost-effective algae cultivation systems. Algal biomass production will be based on the use of industrial flue-gas CO_2 and wastewater, followed by cell harvesting and lipid or polysaccharide extraction for conversion to bio crude oil or alcohols, respectively. These will be upgraded to jet and military fuels at existing US oil refineries. At the same time we will optimize co-product generation, such as fish food, animal feed, and methane from algal biomass to improve process economics.
4. **Anaerobic Digestion Technologies:** Based on our expertise in anaerobic digestion research, we will develop cost-effective integrated anaerobic digestion systems to produce bioenergy (methane) and bio

fertilizer from organic Florida feedstocks, including purpose-grown energy crops, algal press cake, crop residues, food waste, and other organic materials. In partnership with Florida farmers, food processors, and grocers we will optimize the anaerobic digestion of these materials for production of methane-rich biogas that is readily converted to electricity or used in natural gas systems.

Harnessing Florida's Solar Energy

Solar energy is a ubiquitous clean energy resource, and great progress has been made in recent years to develop advanced technologies to harness its potential to enable power production for the grid, domestic power production and heating, thermal desalination, clean fuel production, industrial process heat, and solar cooling, among others. The State of Florida has substantial solar energy resources and a strong incentive to take on the national grand challenge economical solar energy conversion through sustained research and development of the next generation solar energy technologies so that a robust solar energy industry is grown from within. Because solar energy is an intermittent energy source it is essential that solar energy collection be coupled with energy storage technologies to be economically impactful. Numerous storage solutions are being pursued, including thermal, thermochemical, and electrochemical. FESC is prepared to lead a rigorous and transformational research effort to develop the next generation solar energy technologies that will reach levelized cost parity with fossil energy power production. The following are some of the areas to focus:

1. **Photovoltaics: A.** Florida researchers have been the global leaders in the development of thin film photovoltaic cells including CdTe and CIGS. However, some of the materials are rare. Replacement of these materials with earth abundant materials and development of large area cells would help establish new PV manufacturing industry in the State and increase job growth. **B.** Developing highly integrated and smart power electronics to convert solar energy and connect to the grid is very important to developing highly reliable grid-tie PV system. **C.** In addition smart electronic approaches and new materials and processing can be used to improve the performance of the PV panels by controlling their temperature and keeping the surface dust free. **D**. Transformative concepts in the development of efficient and cost effective super capacitors for smart grid operation of PV.
2. **Automatic Permitting, Automatic Utility Interconnection and Autonomous Operation of PV Systems:** Residential rooftops offer the largest real estate for installing PVs. Widespread adoption of residential PV must address various potential costs, including permitting and auditing of PV systems, the cost of connection/disconnection to the grid, and the cost of volatility of solar radiation. Applied research of system integration and operation is needed in the areas of permitting automation, interconnectivity, communications, voltage control and stability, energy and data management, and advanced control of demand response.
3. **Concentrated Solar Power (CSP):** In order for CSP to reach grid parity the thermal power conversion efficiencies must increase and the costs must decrease and high temperature thermal storage technologies should be employed to increase the power plant utilization factor, especially to enable the sale of power to the grid during peak hours. The research needed includes: a) Development of novel thermodynamic cycles for power production which might include but are not limited to supercritical steam, supercritical CO2, Ericsson, or Brayton combined cycles; b) High temperature thermal energy storage; high efficiency mechanical storage, and combined thermal/photovoltaic power production.
4. **Solar Fuels:** Gaseous and liquid fuels can be produced using solar energy by converting water and CO_2 to syngas which can be used directly or converted to liquid fuels such as jet fuel using Fischer Tropsch synthesis. Various approaches to liquid fuel production are available, including PV-Electrolysis, Thermochemical, and Photosynthesis. There is great interest to develop some of these technologies with the potential to start a new type of industry in Florida and lead to job growth.

5. **Heating, Cooling and Clean Water:** a) Another transformative application for solar energy within the State of Florida includes thermally driven refrigeration and cooling. Highly absorbing and desiccant materials such as zeolites and metal hydrides may pave the way for innovative new thermal refrigeration and cooling systems that can operate using solar energy. Other desiccant materials such as Lithium Chloride give us an opportunity to design Desiccant/vapor compression hybrid cooling systems with high potential COP. b) Solar Desalination can play a very important role in providing abundant clean drinking water for Florida. Technologies may include but are not limited to humidification/dehumidification, thermodynamic cogeneration of power and water, and reverse osmosis operated by solar power. c) Solar photocatalytic technologies for clean water have improved a lot and can become commercial. However, additional research to extend the wavelength range to utilize the visible light would increase the effective use of sunlight and reduce costs. d) Solar heating, cooling and desalination technologies should include thermal energy storage to allow their utilization when sunlight is not available.

Power Generation by Using Marine Hydrokinetic (MHK) Resources

Covering more than 70% of Earth's surface, the oceans collect and store the sun's vast energy quite effectively, which is available 24/7 in various forms (tides, waves, ocean currents, gradients, etc.). Surrounded by the ocean on three sides, and with the second longest coastline of all U.S. states, Florida is uniquely positioned to harness marine renewable energy resources. Several forms of marine renewable energy that could soon be cost-competitive with fossil fuel sources for utility-scale power generation have emerged in Florida – ocean current energy, ocean thermal energy, and offshore wind. Each still requires investment in technology development, environmental research, and policy issues, but realization of commercial power generation from these sources will yield energy security, sustainability, and a more diverse renewables portfolio for the state.

1. **Ocean Current Energy:** Ocean currents flow in complex patterns governed by the wind, by the water's salinity and temperature, by the shapes and highly variable depths of the ocean basins, and by Earth's rotation. Most ocean currents are driven by wind and by solar heating of surface waters near the equator, while some currents result from density and salinity variations within the water column. Converting these currents into usable electrical power requires equipment to transform flowing water into mechanical energy and then to electricity (i.e., rotating turbines or linear "kites"). In particular, an ocean current resource is primarily found offshore Southeast Florida, in the channel between Florida and the Bahamas—the Florida Current portion of the Gulf Stream. The Southeast National Marine Renewable Energy Center (SNMREC), designated by the U.S. Department of Energy, has been assisting a growing ocean current energy sector to identify and reduce various barriers to commercial implementation. Although still an emerging market, the ocean current energy sector promises not only to be a unique opportunity for Florida to establish an international expertise and capability, but a significant base-load power source for its residents and businesses in the coming decades.
2. **Ocean Wave Energy:** Electric generation from ocean wave energy could provide plentiful clean and sustainable energy to Florida. Through collaboration with Harris Corporation, innovative concepts including a wave buoy (for an array deployment in the sea) and an oscillating wave column (with a uni-directional impulse turbine for coastal deployment) have been developed, and laboratory prototypes have been tested. The development of large-scale generation systems that can be robust to extreme weather conditions is critical in the state of Florida.
3. **Ocean Thermal Energy:** The SNMREC is also investigating ocean thermal energy conversion (OTEC) potential, the process by which the temperature difference between the ocean's warm surface and cold deep water is used to generate power. Long pipes pump abundant cold water to the sea surface which, in conjunction with warm water, turn turbines that generate electricity, albeit with low efficiency. Although

typically only found in areas of the tropical oceans with greater than 1000 meter depth (like the southern portions of the Gulf of Mexico), portions of the Southeast Florida coast exhibit unique characteristics where required temperature differences are found in less than 300 meters depth. This technology was demonstrated in Hawaii and other places around the world late in the 20th century, but further developments are needed to achieve cost-competitive generation, especially further offshore from coastlines. While large OEMs such as Lockheed Martin Corp. are proceeding with floating OTEC technology development in other parts of the world, utility-scale power generated from this marine renewable resource is most viable for the continental U.S. in Florida, but unique challenges (like high current conditions) must be tackled before full implementation.

4. **Offshore Wind:** Wind power is the fastest growing source of renewable energy, with worldwide production doubling every three years. Wind is converted to electricity using 50 to 100 tower-mounted wind turbines, arranged as a wind farm. Offshore wind, considered to be a marine renewable energy resource, is not affected by the roughness of the land surface (topography, vegetation, buildings) and so presents an attractive potential. Large-scale offshore wind resource maps reveal potential for wind power in Florida's coastal waters. Offshore wind farms are usually built in relatively shallow water, and Florida's wide continental shelves present ample opportunities for their placement outside of coastal view sheds. FESC scientists have found that the northwestern Gulf of Mexico has the potential to generate several thousand megawatts of power for Floridians. The study will ultimately help determine whether wind is a viable renewable energy resource for Florida and whether it is capable of supporting a new industry and the jobs and revenue that could come with it.

RESEARCH PROGRAM

The FESC research program included 84 FESC funded projects within the seven strategic thrusts. The project descriptions are all given in Appendix A. Eight projects from FIU (not funded by FESC) and 1 project from UWF (not funded by FESC) are also included. Some of the projects are collaborative multi-university projects; however, only the lead university information is listed in the table. The majority of these projects have been completed. Table 1 below presents the list of the 14 active/recently completed FESC projects during the reporting period. The energy education project progress reports are given on page 23 of this report. The other progress reports are given in Appendix D of this report.

2011 Florida Statutes 377.703, Additional functions of the Department of Agriculture and Consumer Services states that the department shall serve as the state clearinghouse for indexing and gathering all information related to energy programs in state universities. Per Office of Energy's request, the list of energy-related projects within FESC universities were gathered, complied, sorted by energy topic, and posted at the FESC web site under "FL University Research": http://www.floridaenergy.ufl.edu/?page_id=9144. The projects are listed in Appendix E of this report.

Table 1: Active and Completed FESC Projects during This Reporting Period

Projects	Summary
THRUST 2: Enhancing Energy Efficiency and Conservation	
1	**Title:** Unifying Home Asset & Operations Ratings: Adaptive Management via Open Data & Participation **PI**: Mark Hostetler, **Co-PI:** Hal S. Knowles, III - UF **External Collaborators:** Nick Taylor (Ph.D. Student, UF School of Natural Resources & Environment), Jennison Kipp (Assistant In, UF Program for Resource Efficient Communities) **Status: Active**
THRUST 3: Developing Florida's Biomass Resources	
1	**Title:** Simulation and Measurement of Biomass Suspension Rheology **PI:** Jennifer Sinclair Curtis – UF Project Period: 8/2014-7/2016 **Status: Active**
THRUST 6: Exploiting Florida's Ocean Energy Resources	
1	**Title:** Southeast National Marine Renewable Energy Center **PI:** Susan H. Skemp**, Co-PIs:** Howard P. Hanson, James VanZwieten - FAU **Universities:** UCF, FSU, ERAU, University of Miami, Oregon State University, University of Washington, Pennsylvania State University, University of New Hampshire, University of Hawaii, University of Edinburgh, Heriot-Watt University, Nova Southeastern University, Virginia Polytechnical Institute, Florida Institute of Technology, Embry-Riddle Aeronautical University **External Collaborators:** Numerous industry and State and federal government as well as FFRDCs, such as National Renewable Energy Laboratory, Woods Hole Oceanographic Institution, U.S. Department of Energy, U.S. Department of Interior (Bureau of Ocean Energy Management and Regulation and Enforcement), U.S. Department of Commerce (National Oceanic and Atmospheric Administration), and Florida Department of Environmental, Protection, to name a few. **Status: Active**
Education and Outreach	
1	**Title:** Florida Advanced Technological Education Center (FLATE) **PI:** Marilyn Barger - UF **External Collaborators:** Brevard Community College; Tallahassee Community College; Daytona State College; Central Florida Community College; Polk State College; Florida State College at Jacksonville; Valencia Community College; School District Hillsborough County; Florida Department of Education – Division of Adult and Career Education; West Side Technical School; WFI Banner Center for Energy;

	Advanced Technology for Energy and Environment Center (ATEEC); University of West Florida, Dept of Construction Technology; WFI Banner Center for Construction; WFI Banner Center for Alternative Energy; USF College of Engineering; Madison Area Technical College ATE project for Alternative Energy certifications; Milwaukee Area Technical College Energy Conservation and Advanced Manufacturing Center (ECAM); Florida Energy Workforce Consortium (FEWC); TECO; Progress Energy; ISTEC (Ibero Science and Technology Education Consortium). **Status: Completed (will not continue due to lack of funds)**
2	**Title:** Energy Sustainability Course **PI:** Mark Jamison /Michelle Phillips- UF **Status: Active**
3	**Title:** Buildings and Energy: Design and Operation Vs. Sustainability"- An Energy Engineering Course for Florida-specific Building Design & Operation **PI:** Prabir Barooah - UF **External Collaborators:** Dr. Timothy Middelkoop, University of Missouri **Status: Active**
4	**Title:** Renewable Energy Education Program at USF's Patel College of Global Sustainability **PI:** George Philippidis - USF **Status: Active**
5	**Title:** Introducing Specialization in "Sustainable Energy Systems" for Under-Graduate Students in Engineering at the University of West Florida **PI:** Bhuvana Ramachandran and Co-PI: Muhammad Rashid, UWF **Status: Active**
6	**Title:** A Certificate Program to Enhance Sustainable Behavior Change Competencies for Energy---Focused Educational Outreach Professionals **PI:** Laura A. Sanagorski Warner - UF **Status: Active**
7	**Title:** Solar Energy Technologies: Fundamentals and Applications in Buildings **PI:** Cheng-Xian (Charlie) Lin - FIU **External Collaborators:** NA **Status: Active**
8	**Title:** Renewable Energies and Sustainability Education **PI:** Ryan Integlia and Sesha Srinivasan - Polytech **Status: Active (Recent award)**
9	**Title:** Educational Modules in Support of Sustainable Energy Courses **PI:** Juan C. Ordonez, FSU **Status: Active (Recent award)**
10	**Title:** Outreach Activities for FESC **PI:** Pierce Jones, Kathleen C. Ruppert, Hal S. Knowles III, Nicholas Taylor, Barbra Larson, Craig Miller- UF **Status: Completed**

NEW PROGRAM DEVELOPMENT

The new program development effort aims to facilitate the submission of multi-faculty, multi-SUS university competitive proposals in response to solicitations for major research programs. By collecting the best research expertise in the SUS, competitive funding requests to federal agencies, national and global foundations, and industry can be made. **138 funding opportunities** were distributed to the FESC faculty during this period. The list of funding opportunities is given in Appendix C. The funding opportunities are also posted at the FESC web site: http://www.floridaenergy.ufl.edu/?page_id=912. Faculty teams were formed to respond to the funding opportunities based on the responses received from the faculty. The FESC office facilitates proposal development in a variety of ways beyond solicitation awareness, including identifying leaders, communicating with external partners in industry, national labs and other non-SUS universities, arranging telecons, providing support letters, and finding ways to meet the cost share requirements.

Proposal Development Facilitation

The notable proposals submitted by FESC universities during the reporting period include:

- UCF, UF, FSU, UTT: Concept paper submission in response to DE-FOA-0001263: Manufacturing Innovation Institute For Smart Manufacturing: Advanced Sensors, Controls, Platforms, and Modeling for Manufacturing
- University of South Florida, University of Central Florida, and Florida State University's collaborative proposal. Application to the US Department of Energy's call DE-FOA-0001252. Dr. Lingling Fan led the team and submitted a proposal titled as "R&D Program on Cybersecurity for Power Grids in Florida
- USF response to DE-FOA-0001285 - U.S.-China Clean Energy Research Center: Energy and Water
- Collaborative proposal with Algastar Inc., FAMU (Dr. Ashivini Chauhan) and UCF/FSEC (Dr. Ali Raissi). Sent a proposal as a response to DE-FOA-0001162 - Targeted Algal Biofuels and Bioproducts (TABB). Also USF faculty collaborated with NREL (lead) to submit a proposal.
- UF Faculty response to NSF Partnerships for Innovation: Building Innovation Capacity (PFI: BIC)
- UCF/FSEC response to DE-FOA-0001117: "Building America Industry Partnerships For High Performance Housing Innovation"
- UF Faculty response to DE-FOA-0001166 - Building Energy Efficiency Frontiers and Innovation Technologies (BENEFIT) – 2015
- UF response to DE-FOA-0001167: Buildings University Innovators and Leaders Development (BUILD) - 2015
- UF response to DE-FOA-0001168: Advancing Solutions to Improve the Energy Efficiency of U.S. Commercial Buildings
- UF/USF/ UCF-FSEC response to DE-FOA-0001197: Advanced Research in Dry-Cooling (ARID)
- FSU response to ARPA -E : DE-FOA-0001198 - Generators for Small Electrical and Thermal Systems (GENSETS)
- UCF response (PI: Dr. Bahaa Saleh) to $100 million competition for an Integrated Photonics Manufacturing Institute. Introduced faculty from other FESC universities to this team.
- UF, UCF-FSEC, USF response to DE-FOA-0001220: Sustainable and Holistic Integration of Energy storage and Solar PV (SHINES)
- FAU / UF response to DE-FOA-0001207 - Systems Biology Research to Advance Sustainable Bioenergy Crop Development
- UF response to NSF 15-507: Scalable Nanomanufacturing (SNM); FIT/UF//Mainstream Eng response.
- UCF/FSEC response to DE-FOA-0001195: Physics of Reliability: Evaluating Design Insights for Component Technologies in Solar 2 (PREDICTS2)
- UF response to N00167-15-BAA-01- Energy Conservation Applications for the U.S. Navy
- FSU White paper submission to N00167-15-BAA-01- Energy Conservation Applications for the U.S. NAVY

- UF and USF response to DE-FOA-0001261: OPEN 2015
- UF/TCERDA application to USDA on feedstocks (Funding received)
- UF, UCF, FSU response to FDACS OOE call on Multifamily Energy Efficiency Scoring Tool
- UF in collaboration with G4 and Solar Impact Inc.; UCF response to US DOE SUNSHOT SHINES call
- USF response to ARID for ARPAe and APOLO for DOE-EERE
- UF response to Energy Audits USDA RDBCP-REAP-2015
- UF Response to Analysis, Comparison, and Contrast of Two Primary Maintenance Contracting Techniques used by the Florida Department of Transportation RFRP - 14/15-002
- UF response to FY2015 Vehicle Technologies Office Incubator DE-FOA-0001213
- USF and UF response to DE-FOA-0001289 ARPA-E: Network Optimized Distributed Energy Systems (NODES) Program
- UF response to US DOE Computational Materials Sciences (DE-FOA-0001276)
- USF and UF response to DE-FOA-0001252 - Academic Collaboration for Cybersecurity of Energy Delivery Systems (CEDS) Research and Development for the Energy Sector
- USF response to DE-FOA-0001239 - Technology Development and Assessment for Supercritical Carbon Dioxide (SCO_2) Based Power Cycles

Some award examples are given below:

- UCF received an US DOE award to study advanced whole house residential construction practices for production builders that can achieve 50% whole house energy savings compared to houses built to code in hot/humid climates. The project will work directly with leading production builders to: 1) demonstrate and validate a new cost-effective attic insulation system that is much more energy efficient; 2) demonstrate and validate high efficiency variable capacity space conditioning systems that better manage comfort and cost tradeoffs in low load homes; and 3) test a new "smart" ventilation system innovation that controls air temperature and humidity while maintaining indoor air quality.
- UF received an US DOE award to perform research on Used Fuel Storage Monitoring Using Helium-4 Scintillation Fast Neutron Detectors and Neutron Spectral Analysis. Funding amount: $799,765.
- UF received an US DOE award to perform research on Multimodal Nondestructive Dry Cask Basket Structure and Spent Fuel Evaluation. Funding amount: $3,000,000.
- Dr. Moghaddam at UF, in collaboration with Prof. Mark Orazem (ChemE), teamed up with Fortune 500 chemical company Mosaic under a $1.5M grant to develop a process for continuous electrokinetic dewatering of phosphatic clay suspensions. Phosphate clay suspensions are a by-product of strip mining, rendering large land areas unusable for development. Electrokinetic dewatering offers the opportunity to reclaim these areas and save water and energy. In addition, he received a $0.8M Department of Energy (DOE) award, in a partnership with Oak Ridge National Laboratory (ORNL) and General Electric (GE). Dr. Moghaddam's group is studying the physics of an ultrasonic drying process for fabrics as an alternative approach to conventional energy-intensive thermal-based drying.
- UNF received a NSF award in collaboration with MIT to perform research on Understanding and Engineering the Timing Precision of Superconducting Nanowire Single Photon Detectors. Funding amount: $530,000. With this grant, UNF and MIT will work together to improve high-tech superconducting electronics and sensors through research on a phenomenon known as “photodetection jitter.” These cutting-edge quantum electronics hold incredible promise because of their high speeds, nanoscale size, and timing precision, which is why they’re so important for the future of technologies such as space communications, ultra-sensitive sensors, and quantum computation.
- USF received a NSF grant to perform research on Graphene Heteromaterials. Funding amount: $620,000.
- USF received a NSF EAGER grant to study: Development of a Rectenna for Energy Harvesting and Detection Applications; Funding amount: $280,000.
- USF received a NSF grant to study: A novel algal-bacterial shortcut nitrogen removal process for wastewater treatment; Funding amount: $330,000

- USF received an US DOE grant on Photocatalysis of modified transition metal oxide surfaces. Funding amount: $450,000

Energy Crop Certification Workgroup

The primary goal of this program is to make alternate crops available for the farmers to make lost citrus land productive again. The development of new hybrids, new cultivation methods and processing technologies of Advanced BioFuel (ABF) and Advanced BioChem (ABC) crops hold tremendous promise but face substantial regulatory, technological and cultural barriers that prevent supply chain adoption. Energy Crop Certifications are handled by EPA; however due to demand, getting an approval takes a very long time. Businesses requiring certifications use service providers. The service providers work with National Labs to meet the requirements of the certification process. Life cycle analysis and greenhouse gas (GHG) emission reports are part of the requirements. A road map development in our state is needed to streamline the EPA requirements to speed up the energy crop certification process.

FESC Office established a FESC faculty workgroup in collaboration with Treasure Coast Research Park to provide a "Workflow Process and Implementation Plan" to FDACS/Office of Energy to implement a statewide Advanced Biofuel (ABF) Feedstock Certification Program.

The key deliverables of the workgroup are:

- Outline what FESC can do to speed the ABF Feedstock Certification Process for Florida ABF crops.
- Develop a primary and secondary list of Florida target crops for potential ABF certification.
- Identify EPA, USDA and industry stakeholders, their certification needs, and baseline data requirements for completion of a typical ABF crop Feedstock certification report.
- Recommend ABF crop Feedstock certification program targets (number of certifications per year), credential requirements, certification report content, and format to FDACS/Office of Energy.
- Provide guidance for funding the ABF crop certification program. Identify respective clients, their certification service needs, and explore current market pricing on similar services.
- Identify Florida research resources and service providers to process ABF crop certification.

Progress: Dr. Gary Peter, UF/IFAS and Dr. John Ericson, UF/IFAS, are collaboratively working to develop the road map for the energy crop certification. The initial telecon with EPA official was held to have a better understanding of the program. The team have assembled and read through EPA documents on new fuel pathways and how to submit petitions. Through these documents, they have identified generally applicable and specific approved pathways, as well as pending petitions. It should be noted that no pathways specifically using sweet sorghum or energy beets have been approved to date. Dr. Peter and Dr. Erickson collected some of the available successful petitions and are reviewing those. They have also assembled and are reviewing EPA documents on the types of information/data needed for submitting a petition. They are currently in the process of identifying sources of data that may be available to support a petition within IFAS or externally if available, particularly from my end with regard to sweet sorghum and energy beet production as identified in the plan of work.

New Grant: FESC is one of the partners along with some of the FL farmers in USDA grant lead by the Treasure Coast Education, Research, and Development Authority (TCERDA). The aim is to perform feasibility study to determine the economic and environmental viability of expansion of the alternative biofuels supply chain in South Florida. This research will investigate the sustainable economic and environmental viability of cultivation and processing of industrial sugar and starch row crops including beets, tubers, sweet sorghum and cane to produce bio-jet fuel, bio-ethanol, bio-diesel fuel, bio-heating oil.

Conferences Attended

FESC administration attends conferences and workshops to expand the FESC network by developing new partnerships. The list of the conferences and workshops attended during the reporting period is given below:

1. Advanced Biofuel Feedstock Roundtable, Ft. Pierce, FL, Oct 1, 2014.
2. Center for Municipal Research & Innovation meeting in Gainesville, FL on Oct 9, 2014.
3. Microgrid Consortium Stakeholder Meeting, USFSP, St. Petersburg, Oct 15, 2014.
4. Caribbean Renewable Energy Forum (CREF), Miami, FL on Oct 6-8, 2014.
5. FESC Advisory Board meeting on Dec 3, 2014, hosted by OUC.
6. Justin Sayfie, Orlando, FL on Dec 4-5, 2014.
7. Renewable Energy World Conference & Expo North America, Orlando, FL on Dec 9-11, 2014.
8. UF COE Engineering Summit on Jan 15, 2015: https://www.eng.ufl.edu/news-events/events-calendar/summit2015/summit-agenda/
9. FESC workshop on Feb 2-3, 2015 in Orlando: http://www.floridaenergy.ufl.edu/public-outreach/2015-fesc-workshop/
10. PURC workshop on Feb 4-5, 2015: http://warrington.ufl.edu/centers/purc/docs/agenda_conference.pdf
11. ARPA-E Summit on Feb 8-11, 2015; http://www.arpae-summit.com/Agenda/2015-Summit-Agenda-
12. UF Law School Energy Conference on Feb 13, 2015; http://ufpiec.org/2015-conference/agenda/
13. UF Technology Showcase on March 10: http://research.ufl.edu/otl/about-otl/a-celebration-of-innovation-startup-showcase/a-celebration-of-innovation-startup-showcase-agenda.html
14. SBIR Workshop on March 17, 2015
15. Participated in the Gator Day in Tallahassee on March 24, 2015 to promote FESC.
16. Gave a FESC overview presentation at the Carinata Field Day, North Florida Research and Education Center, Quincy, FL on April 28, 2015
17. FESC May 20-21 workshop in Orlando
18. June 15, 2015: FESC/IBM short Course in Gainesville. http://www.floridaenergy.ufl.edu/public-outreach/fescibm-professional-development-course-june-2015/
19. Bio Energy 2015 in Washington DC (June 23-24, 2015)
20. World Energy Engineering Conference (WEEC) in Orlando on Sep 29-Oct 2, 2015.
21. FL Energy Summit in Jacksonville FL on Oct 14-16, 2015

Numerous new contacts were established at these conferences, meetings, and workshops. Some of the contacts were shared with faculty members for potential collaborations.

INDUSTRIAL COLLABORATION AND TECHNOLOGY COMMERCIALIZATION

FESC's industrial collaboration program promotes exchange between the universities and industrial partners from small, medium, and large companies, as well as other organizations such as incubators, research parks, investors, entrepreneurs, and government laboratories.

FESC has an Industrial Partnership and Innovation Strategy that assures active collaboration with the private sector and other partners that support and guide FESC's vision, collaborate with FESC in our research, education, innovation, and outreach programs.

FESC Technology Commercialization Program Description

FESC has devised a multi-tiered approach to investing its limited technology commercialization resources. In devising this strategy, FESC is focused on 1) fully complimenting the existing resources across the SUS and state of Florida's economic development community, 2) providing the maximum potential return / economic impact to Florida's economy on our investment, 3) maximum leveraging of FESC resources with industrial support, and 4) a focus on driving later stage energy technologies in the FESC university research portfolio toward commercialization. This has led to development of a two-tiered program as outlined below:

Phase I: Early Stage Market Research / Business Plans – Recognizing that a number of FESC funded technologies may have unknown, or at least undocumented, commercial potential and also recognizing that university licensing offices and technology licensees (entrepreneurs, SMEs, large corporations) alike are looking for a greater depth of understanding of potential applications of some of FESC's later stage technologies in order to optimize technology licensing and the path to market, FESC initiated a funding program of business plans and market research studies for select FESC technologies. This program was completed and program details were reported in previous reporting period.

Phase II: Matching Funds R&D Program – The second tier of the FESC technology commercialization funding program is modeled on the very successful Florida High Tech Corridor Council Matching Grants Research Program which has been ongoing at USF and UCF since 1996 and at UF since 2005. This second tier also builds off of the results of the first tier as the business plans and market research studies in tier 1 above will provide for more complete information in attracting industrial partners and selecting appropriate projects for funding in tier 2. In this program, FESC core universities will propose energy related projects for FESC funding that is matched on a 2:1 basis by industry funds. This model serves a number of purposes: 1) industry partners are by definition highly engaged in the development process in the university as they are co-funding the R&D package, 2) this provides at least a 2X leveraging of FESC funds on each project, 3) a natural pipeline of the technology deployment to the private sector partner is established as they are typically working on development aspects in parallel with the university research on the project, and 4) the FHTCC program has proven time and again that this model spawns new and long lasting R&D collaborative relationships between companies and SUS university researchers. FESC envisions providing up to $50K in matching funds for each project and with industry match (summarized in table below) on each project, attracting in excess of $500K of industry support to these FESC funded projects.

Progress Made During the Reporting Period

Both Phase I and II projects were completed. New projects will be funded when new funding is received. FESC office continues to work with faculty and industry to create new collaborative projects.

Companies Contacted and/or Assisted

The companies we are in communication are listed at FESC web site based on area of expertise (under different sub menus): http://www.floridaenergy.ufl.edu/?page_id=11727

Companies/organizations contacted and/or assisted during the reporting period are given below.

Some examples of collaborations:

RES Polyflow: Looking for a new location to move to FL. Working with Gainesville Chamber to attract them Gainesville location.

IBM: Organized a professional development course titled as "Cloud and Mobile Technologies Changing Your World" at UF in collaboration with IBM.

Viesel Fuel LLC – Located in Stuart, Florida. They have a 7.5 million gallon/year biodiesel facility that is pioneering the use of enzymes and resins to access lower-quality feedstocks in the production of ASTM D6751 certified biodiesel. The enzymatic and resin technologies employed by Viesel require less energy than traditional biodiesel production, thereby reducing greenhouse gas emissions, and can be constructed for a lower capital cost than traditional biodiesel plants. Visited the company to better understand their process and assist. Introduced the owner to Dr. David Wright, UF faculty, who is performing field tests with Carinata (oil crop). Viesel tested Carinata oil sent by Dr. Wright with great success. They want to work with Dr. Wright and FESC faculty to test other oils. Viesel attended the Carinata Field Day, North Florida Research and Education Center, Quincy, FL organized by Dr. Wright on April 28, 2015.

Commercial Aviation Alternative Fuels Initiative (**CAAFI) –** Rich Altman, Executive Director Emeritus, is one of the members of the Energy Crop Certification work group. We are having meetings and telecons to develop a roadmap for the certification process.

Treasure Coast Research Park - Ben Devries is co leading the energy crop certification work group. Team members had a telecom with an EPA official to initiate the road map development.

Peerless Wind Systems: Communicated with the founder. Posted their company information on FESC site. Introduced the founder to FESC faculty in this area.

25x'25 Alliance: Participating their monthly telecons and introducing FESC to new attendees.

Algastar Inc.: Introduced the CEO to FESC faculty for collaborative proposal development.

Reserve Power Solutions: Start-up company seeking university partner for development of its proprietary power (not a battery) storage technology and a system for storing power which is complimentary of intermittent power sources (solar and wind). The commercial objective is to resolve the "intermittency" gap in natural power sources and/or provide a source of supplement power during peak demand periods. Waiting for further information from the owner to introduce him to the faculty in the area of expertise needed.

Keuka Energy: Wind Energy Company developing technology to compress air with wind energy (then liquefy it) and sell it to utilities as a replacement for spinning generators. Introduced the owner to our utility contacts.

GreenTech Endeavors LLC: GreenTech Endeavors (www.greentechendeavors.com) is a cleantech incubator. They license clean technologies from Florida Universities to bring them to market and/or invest in cleantech startups. FESC office introduced the FESC faculty technologies to Will Perego, Founder & CEO, GreenTech Endeavors for licensing. Technologies licensed or in consideration are:

From UCF Faculty Dr. Issa Batarseh (MaxHarvest Microinverters LLC): World's first 3-phase microinverter. GreenTech Endeavors have a Licensing Agreement with UCF and are negotiating a Sponsored Research Agreement.

From FIU Faculty Osama Mohammed (EnerMaster LLC): GreenTech Endeavors has an Option Agreement with FIU to license the technology and are negotiating a Sponsored Research Agreement. Another technology from FIU is under consideration and kept confidential at this point.

From UM: FlashCharge Batteries LLC: www.flashchargebatteries.com. GreenTech Endeavors is finalizing the first year of the sponsored research agreement with UM and have an Option Agreement to license the technology. Another technology from UM is under consideration and kept confidential at this point.

In addition to the above, the industry members communicated/collaborated include, ABB, AGT, Algenol, Algastar Inc. , Amyris, Arsenal Venture Partners, Amzur, ASERTTI (http://www.asertti.org/), Aquantis Inc., Battery Innovation Center, IN, BioFuelNet Canada, Bing Energy, Bryant Miller Olive, Bruderly Engineering Associates, Inc., BurCell Technology, BP, CAAFI, Canadian Consulate, Chemergy, Citizen for Clean Energy, Conscious Entrepreneurship Foundation, Dayaway, Deloitte, Duke Energy, EcoUrbana, Eco-smart Inc., EIW Corp., Encel, Florida Earth Foundation, FPL, Gainesville Renewable Energy Center, Gainesville Area Chamber of Commerce, Garmor Inc., General Capacitors, Greener Earth Financial Solutions, Greenstar Panels, G4 Synergetics, GreenTech Endeavors LLC, Grotto, GulfCoast Energy network, HyPower Inc., Hydro-Electric Farms, Inc., Hydromatic Technologies (Dryers), IBM (Organized a short course in collaboration with IBM), INEOS, International Institute for Sustainable Laboratories (I2SL), Ivy Composites, Lockheed Martin, Mainstream Eng., Manny Garcia (Pool co), Nhu Energy, NIST, OUC, NiteBloom, Parker Hannifin Corporation, Peerless Wind Systems, Pi-Innovation Inc., Power Tree, Reserve Power Solutions, RES Polyflow (Looking for a new location to move to FL. Working with Gainesville Chamber to attract them Gainesville location), Saft, Smart Grid Consulting Associates (SGCA), Sicarga, Siemens, SafGlass, Sunstreet Energy Group (Lennar Co), South Wire, Southeastern Coastal Wind Coalition, Southern Co, Space Florida, Supreme Suites LLC, Tampa Bay Water (Desalination Plant), Telular Corp, Tek Vise, TerViva Inc., TIRC Energy Engineering, International (representative for Saf Glass), The Balmoral Group, Trans World Energy L.L.C., Treasure Coast Research Park, TriSect (Steven Seibert, Co-founder), US DOE, USDA, UN- Pakistan, Watson, World Future Society, World Housing solutions (Www.WorldHousingSolution.com), 25x'25 Alliance.

International Collaborations:
These international collaborations are for solar energy and other energy research, development and deployment at the following (Ref: Dr. Yogi Goswami):
Agricultural University of Athens, Greece, BrightSource Industries, Israel, Delhi Technological University, India, DEMOKRITOS National Centre for Scientific Research, Greece, Global Cool Cities Alliance, South Africa, IMDEA Energy, Spain, Keilir Atlantic Center of Excellency, Iceland, Nanjing University of Science and Technology, Solar Energy Institute for India and the United States, India, Tel Aviv University, Israel University of Santa Catarina, Brazil.

EDUCATION

The Education program has three focus areas, community college programming at the Associate of Science and certificate level, nuclear energy education, and Undergraduate/Master's degree in sustainable energy.

The Community Colleges offer an opportunity to develop a trained energy workforce through programming for both technician level 2 year students, as well as students planning on completing a Bachelor's degree.

FESC works closely with the Florida Community College system as well as with the Florida Advanced Technological Education Center (FLATE), which coordinates the design of industry specific training programs for technicians at the community colleges in Florida. FESC disseminates energy curricula in cooperation with FLATE.

On the Collegiate Level, programming includes curriculum directed at the workforce for the nuclear industry and development of classes for undergraduate/master and energy certification program.

Progress Made During the Reporting Period

Progress reports on existing and new programs (nine grants) are given below.

Florida Advanced Technological Education Center (FLATE)

PI: Dr. Marilyn Barger, Hillsborough Community College

FLATE External Collaborators: Brevard Community College; Tallahassee Community College; Daytona State College; Central Florida Community College; Polk State College; Florida State College at Jacksonville; Valencia Community College; Palm Beach State College; School District Hillsborough County; Florida Department of Education – Division of Adult and Career Education; West Side Technical School; USF College of Engineering; Madison Area Technical College ATE project for Alternative Energy certifications; Milwaukee Area Technical College Energy Conservation and Advanced Manufacturing Center (ECAM); Florida Energy Workforce Consortium (FEWC); TECO; Progress Energy; ISTEC (Ibero Science and Technology Education Consortium), Usurbil GLBHI (Spain); TKNIKA - Innovation Institute for Vocational Training (Spain); Center for Energy workforce Consortium (CEWD); UF Industrial Assessment Center; CREATE NSF Center for Alternative Energy; EST2 NSF ATE Grant project; DOE's Office of Energy Efficiency & Renewable Energy; Gulf Coast State College; Palm Beach State College; University of South Florida's College of Engineering; University of Miami; University of Alabama; Rutgers University; Energy Reduction Solution, SMC Corporation of America, Energy Conservation Group; Florida Solar Energy Consortium; Tampa Bay Regional Business Plan Energy Efficiency and Conservation Sub-Committee.

Summary

FESC partnered with Florida Advanced Technological Education Center (FLATE) to develop statewide curriculum frameworks for technical A.S./A.A.S. degree programs supporting existing and new energy business sectors.

FLATE develops and processes through the FLDOE the industry-validated student competencies of the frameworks. FLATE also develops new courses required for each new program of study. Additionally FLATE helps state and community colleges implement the new frameworks in their institutions. To support the new curriculum, FLATE works closely with the FESC Public Outreach and Industry Partnership programs to provide professional development opportunities for teachers and faculty to upgrade and update their knowledge base.

Project Activities, Results and Accomplishments

Fourth Annual FESC State College Energy Workshop
This year's event is scheduled for May 22nd, 2015 from 9 a.m. to 4 p.m. at Hillsborough Community College (HCC) Brandon Campus. Presenters include Jay Matteson – Director of Institute for Energy & Environmental Sustainability (Palm Beach State College), April Harley – Supplier Diversity, Business Development (Duke Energy) and Kathryn Frederick Wheeler – State Supervisor of Architecture & Construction / Energy, Florida Department of Education. The afternoon session will include a panel of individuals who work with sustainability at their colleges and tour of HCC. Lunch and refreshments will be provided. A registration fee is not charged for the workshops, but pre-registration is required.

Annual FESC Workshop/Forum Participation
FLATE's abstract "Matching Training to Industry Needs: FLATE-FESC Grant Accomplishments 2008-2015" was accepted and staff will present their work as a poster and orally at the annual FESC Workshop in the Education and Workforce sessions in Orlando on May 20th, 2015.

Expansion of Colleges' Sustainability Efforts
FLATE conducted extensive research to find out which colleges are currently engaged in college-wide sustainability programs and of these, which have staff dedicated to sustainability on their campus. The resulting article, "Sustainability in Florida Colleges", was published in the FLATE FOCUS newsletter and on the FESC website. In addition, findings will be shared at the Florida Colleges Energy Education Forum in May, during the sustainability panel comprising individuals directly involved in sustainability on their campuses.

Additional Course Development
FLATE will be supporting new courses expected to be required for both the Smart Grid Technician program and the Relay Technician program at Lake Sumter State College. Skills definitions are just now being outlined from industry and work will begin mid-late summer.

College Program Implementation Assistance
FLATE has been working with Lake Sumter State College on development of the Electrical Relay Specialization for the Engineering Technology Degree that will start this Fall, 2015. New curriculum frameworks are being developed and new courses added to the program. FLATE has also worked with Palm Beach State College on their Alternative Energy Engineering Technology certificate program and on the development of a Smart Grid Certificate attached to their Electrical Power Technology, A.S. degree program. FLATE has been a mentor for both colleges providing guidance and review of programs and courses. Both colleges now regularly attend the Engineering technology Forum and the annual FESC Florida Colleges Energy Education Forum.

FLDOE Framework and Course Reviews
FLATE assisted the Florida Department of Education in the review of the curriculum framework and content for the 'Fundamentals of Energy' and 'Introduction to Energy and Career Planning' courses. This effort is preliminary to the work for articulation development in #9 below, which will begin early this summer.

Smart Grid Technologies Feasibility and Workforce Needs
FLATE coordinated an occupational analysis workshop for the Smart Grid Technician program in Florida, April 23-24 at Palm Beach State College. The workshop was facilitated by the Advanced Technology Environmental and Energy Center (ATEEC) and sponsored by the National Science Foundation (NSF). This is one of many Job Task Analysis (JTA) workshops being held across the country to better inform and guide our educational communities as they attempt to meet the emerging technician-level workforce demands in the area of energy technology.

Participants included 12 smart grid content experts from the education and industry realms as well as individuals who have an understanding of how existing courses for secondary students connect to students enrolling in Electrical Power Technology and Engineering Technology programs at the postsecondary level. The workshop will took place over two days with the goal of gathering input on the real-world tasks and functions of the Smart Grid Technician job. The report generated will be published and available for download in June 2015.

Articulation Development for Fundamentals of Energy Certification
Florida Energy Workforce Consortium Planning Meeting, Orlando - (January, 2015)
The meeting was held by FEWC and hosted by Siemens to solicit outside input in shaping the future of the consortium. FLATE highlighted the FESC/EST2 Summer Camps and Camp-in-a-Box resources, which are now posted on the FETN site. **FETN Meeting (June 2015)**
FLATE will be presenting at the Florida Energy Teachers Network (FETN) Workshop in Longwood, June 17-18 and is working to develop an articulation for the Fundamentals of Energy Certification to the existing A.S. Engineering Technology / ET Core and Energy specializations.

Dissemination at Community College Workforce Venues
Florida Energy Teachers Network Meeting (June 2015) - FLATE highlighted the FESC/EST2 Summer Camps and Camp-in-a-Box resources, which are now posted on the FETN site.
FESC Research Workshop – May, 2015 - "Matching Training to Industry Needs: FLATE-FESC Grant Accomplishments 2008-2015"
Florida Colleges Energy Education Forum – May, 2015 - Sustainability in Florida Colleges
Engineering Technology Forum – April, 2015 – Partnered with Lake Sumter State College to present on their A.S. Engineering Technology Degree with Relay/Substation Tech Specialization Degree. RCNET also presented on the ongoing work at their center, particularly in Florida.

Newsletter Articles
FLATE submitted an article for the Fall FESC Newsletter, "Sustainability Staffing in Florida Colleges" and will be submitting an article about outcomes of the recent Job Task analysis Workshop for the Smart Grid Technician program for the Spring/Summer newsletter.

The FLATE project ended due to lack of funds.

Buildings and Energy: Design and Operation vs. Sustainability

PIs: Dr. Prabir Barooah, Dr. Duzgun Agdas, and Dr. Ravi S. Srinivasan

Project start date: May 16, 2014
Project end date: May 15, 2015

Summary
To achieve higher standards in building design and operation, a solid foundation of energy engineering and sustainability principles is essential. At UF engineering, there are no courses offered to students and industry professionals in energy topics particularly related to buildings, specifically for the design and operation in

Florida climate conditions. This project fills this void through the development of an energy engineering course.

Goals and Objectives

1. To develop and offer an online undergraduate/graduate energy engineering course for Florida-specific building design and operation.

Project Activities, Results and Accomplishments

Progress made during the reporting period:

- The undergraduate / graduate course was mostly designed during summer and Fall 2014, and was taught in Fall 2014.
- Application for permanent course number has been filed in Summer 2014. The permanent numbers have not been assigned yet. As a result, the course was taught in Fall 2014 under "special topics" course numbers EML 6934 / EML 4930 under the Mechanical and Aerospace Engineering Department.
- This course is also available via UF Edge (online course). Video recordings of all lectures are available in UF Edge for access by students taking the online version of this course.
- For the benefit of the State of Florida, the building energy modeling project specifically focuses on a retrofit of an existing building in UF campus, i.e., Rinker Hall. The selection of this retrofit project was crucial as students will learn the issues related to Florida-specific climate and the nuances of modeling, calibration, and improving building energy efficiency.
- In Fall 2014, 13 students (8 graduate students and 5 undergraduate students) enrolled in its first term. More students and industry professionals are expected to join in the coming years as the course is advertised via UF EDGE and the course is moved to the college of engineering rather than in a specific department.
- The course was enthusiastically received by the students. Among the three sections of the course and among the three instructors, the student evaluation on 'instructor overall' ranged from 3.5 to 4.75.

Concluding Remarks

This engineering course is a game-changer in respect to buildings and energy. As the course delivery is completed by end of Fall term, the PIs have planned to focus on advertising this course to industry professionals in the State of Florida with a view to greater enrollment and impact in subsequent offerings.

Publications

None, but a conference presentation in planned based on experience with designing and teaching the course, perhaps in an upcoming ASEE (American Society of Engineering Education) conference.

Renewable Energy Education Program at USF's Patel College of Global Sustainability

PI: George Philippidis, Ph.D., University of South Florida (USF)

Project Description

Renewable energy has been growing significantly in recent years due to energy security and environmental concerns and thanks to fast-dropping costs. The goal of this project is to establish a new, fully online and on-campus concentration in Renewable Energy as part of the College's existing M.A. in Global Sustainability. The energy concentration will help the State of Florida educate, train, and prepare students for green jobs.

Budget: $85,101

Universities: USF

External Collaborators: Culture Fuels Inc. and Dr. Steve Clarke (retired from Florida Crystals Corporation)

Summary of Progress

(1) *Renewable Transportation Fuels* (IDS 6207)

The course was offered for the first time in Fall 2014 on campus (session 001) and on line (session 201) and was designed and taught by Dr. Philippidis. The first roster consisted of 13 graduate students in class and 4 graduate students on line.

The course focuses on conventional renewable fuels from corn, sugarcane, and vegetable oils and advanced biofuels from cellulosic biomass and algae. Technology, economics, financing, policy, market, regulatory, and sustainability aspects are discussed in detail.

The course includes guest speakers from the industry. Course evaluations in Fall 2014 were very complimentary with an instructor overall rating of 4.9/5.0 from the on-campus students (response ratio 77%) and a rating of 5.0/5.0 from the on-line students (response ration 75%). Recommendations by the students are currently implemented in Fall 2015.

(2) *Renewable Power Portfolio* (IDS 6208)

The course was offered for the first time in Spring 2015 as part of the Patel College's MA in Global Sustainability: on-campus (session 001) and on-line (session 201). It was designed and taught by the PI of this grant (Dr. Philippidis). The roster consisted of 23 graduate students on campus and 5 graduate students on line, a 65% increase in enrollment over Fall semester's energy course.

The course focuses on the various forms of renewable power: solar water heating, photovoltaics, concentrating solar power, wind, geothermal, bioenergy, and ocean energy. Technology, economics, financing, policy, market, regulatory, and sustainability aspects are discussed for each of these forms of renewable energy.

The course includes guest speakers from the industry. Course evaluations were very complimentary with an instructor overall rating of 4.84/5.0 from the on-campus students (response ratio 83%) and a rating of 5.0/5.0 from the on-line students (response ratio 60%). Recommendations by the students will be implemented, when the course is offered in Spring 2016.

In summary, the project has progressed according to schedule. A no-cost extension until July 31, 2016 was granted by FESC to allow Dr. Philippidis to implement changes and compare student satisfaction between the academic years 2014-15 and 2015-16.

Funds leveraged/New partnerships created

The courses are now available as electives to graduate students from around the USF system. Students from Engineering and Environmental Science and Policy have already taken one or both courses.

Proposals

A proposal entitled "Development of Sustainable Energy-Water-Food Nexus Course", submitted to FESC for funding on Oct. 31, 2014, is pending.

Publications and Presentations

The project results were presented at the annual FESC Energy Workshop under the title "Renewable Energy Courses for Master's in Global Sustainability". The education session of the workshop was very well attended (May 20-21, Orlando, FL).

Public Utility Economics: International Infrastructure with Focus on Energy Sustainability in Florida and the Nation (Undergraduate level course)

PI Name: Mark Jamison, Public Utility Research Center, University of Florida
Research Interests and Contact Information

Co-PI: Colin Knapp

Description: This project creates a 4 credit hour elective course on energy sustainability offered by the Public Utility Research Center to be taught in the Warrington College of Business Administration (WCBA), a non-credit course offered online, and a video archive that can be used for multiple purposes, including allowing future UF students to access the course online if there are sufficient resources.

Project Start Date: 1/1/2014

Project Development Period: 8/1/2015

Summary
The 4 credit hour economics elective course on the economics of energy sustainability (GEB 4930) was taught in the Fall 2014 and Spring 2015 terms. The course was offered by the Warrington College of Business at the University of Florida. The last offering of the course was recorded so that a non-credit course can be offered online, and a video archive can be used for multiple purposes, including allowing future UF students to access the course online if there are sufficient resources. One of the benefits to the state of the video archive, is that Florida citizens will be able to become better informed about topics related to the economics of energy sustainability.

The course was targeted to upper level undergraduates who had taken Principles of Microeconomics. Most students who registered were Economics majors, but the course also attracted students from the following majors: Marketing, Psychology, Sustainability and the Built Environment, Political Science, Telecommunications, Information Systems, General Business Administration, and Sustainability Studies. Enrollment consisted of 23 students in the Fall term, and 28 in the Spring term.

The course had two exams and a 12-15 page final student project. The project consisted on having students research a sustainability topic and present their results in 10 minute presentations to the class. Students chose to cover a wide ranging set of topics which included: Solar power, Wind power, Sustainability of electrified rail transport in Florida, Nuclear power, Sustainability of agriculture in Florida, Carbon tax, Bioenergy, Biofuel, Energy Reform, EPA's clean power plan, Electric cars, Green Roofs, Natural Gas use in Florida, Ocean Current potential in Florida, Waste Heat Recovery, Natural Gas use in Fleet Transportation, Water Scarcity and Agricultural Irrigation issues in Florida, Sustainability in Urban Environments, Ramifications of Animal Agriculture, Sustainability in the Supply Chain, Biogas, Florida's Coral Reef, Sustainable Architecture, and Sustainability in Aquaculture/Aquaponics.

After all the presentations were completed in the Fall term, four students were selected for a panel on Energy Sustainability at the Bob Graham Center for Public Service which took place on January 15th, 2015. The event was publicized via email to various departments and had relatively high attendance (roughly 50 attendees), it lasted for 2 hours. Attendees included professors and staff members from several departments, parents and family members of the presenters, the general public and students. The event was open to the general public. One of the benefits of this public event to the general Florida public was that people from outside of the University of Florida had access to free presentations on topics of energy sustainability. Attendees asked questions and seemed engaged with the topics.

Picture taken from the Bob Graham Website showing the Bob Graham Center Energy Sustainability Panel.

The course was taught without a textbook. Instead, journal articles and other electronic sources were used in addition to a few book chapters. PURC's Body of Knowledge on Infrastructure Regulation was made available for background reading.

The following topics were covered in the lectures: Infrastructure Utility Market Structure, Energy Sustainability, Electricity Mix, Cost Benefit Analysis, Environmental Policies, Coal, Taxes and Subsidies, Energy Efficiency, Off Grid Solar (applied to poor rural areas), Economics of Climate Change, Renewable Energy Generation, Biofuels, Value of Solar, Transportation, Pollution Abatement, Environmental Law, Public Economics aspects of sustainability issues, Nuclear power, Political Economy aspects of sustainability issues, Intermittency and its Economic Implications, and Cap and Trade.

The course also had several guess lecturers present topics related to sustainability. The topics covered in these guest lectures were (note: only the Challenges in CO_2 abatement lecture was recorded): Clean Air Act Legislation (from an environmental engineering perspective), Challenges in CO_2 Abatement, and the use of Climatology models in hydroelectric dam storage use. The Spring 2015 also attended a public lecture on Smart Grids.

Introducing Specialization in "Sustainable Energy Systems" for Under-Graduate Students in Engineering at the University of West Florida

PI: Dr. Bhuvaneswari Ramachandran, Assistant Professor, Department of Electrical and Computer Engineering, University of West Florida

Co-PI: Dr. Muhammad H Rashid, Professor, Department of Electrical and Computer Engineering University of West Florida

Project Time Period: Aug 2014 to July 2016

Summary and Progress

The objective of this proposal is to introduce a specialization in "Sustainable Energy Systems" for Undergraduate Engineering students at the University of West Florida that could also be used to educate industry professionals towards workforce development. The courses have been designed from the perspective of energy system planning, a subject that has always been complex and evolving rapidly during the past 10-15 years to accommodate dramatic changes in the industry. These changes include the ongoing transformation of the nation's generation portfolio from being heavily dependent on fossil fuels to one that is heavily

dependent on renewables (especially wind and solar) and the need for operating competitive electricity markets.

The courses designed under this specialization will assist professionals in understanding the limits of our present energy systems and lead us to a future in which we can continue to provide reliable and secure energy resources for improved human quality of life. The proposed specialization program focuses on electrical engineering sources and systems that are non-polluting, conserving of energy and natural resources, economically viable and safe for workers, communities and consumers. Coursework takes a systems level and interdisciplinary approach to solving seemingly intractable sustainable energy problems, as opposed to single disciplinary and locally optimized approaches destined to yield marginal positive impacts. Students will be able to create study programs suited to their interests and aspirations through their choice of electives and design projects. The course is electrical engineering-based but also covers a wider range of topics including economics, sustainability and environmental studies.

Discussions to offer this course as a certificate course are going on between faculty and Continuing Education department of the University. According to the designed curriculum, students were to take 4 courses from within the Specialization Core (12 credits) and one elective on Environmental Law.

The timeline for offering courses under this specialization is

Year-1	Fall 2014	Renewable Energy Systems
	Summer 2015	Future Energy Systems
Year-2	Fall 2015	Power Electronics and Drives
	Summer 2015	Sustainable Power Systems: Planning, Operation, and Markets
Elective	Fall/Spring	Environmental Law

Since Oct 2014, the online study material for Future Energy Systems course which is second on the list of courses for specialization has been prepared and lecture notes are setup to aid the students in understanding the significance of sustainable energy systems. Please refer to syllabus below for the detailed course content for this course.

EEL 4990 - Future Energy Systems
Course Syllabus

General Information
Semester: Summer 2015
Course: EEL 4990 Future Energy Systems
Instructor: Dr. Bhuvana Ramachandran
Email: bramachandran@uwf.edu, BR@uwf.edu
Course Description and Scope: Study and analyze renewable energy sources and their integration into the grid, microgrid, smart grid power management, plug in electric vehicles, modern energy storage technologies, energy efficient buildings, cyber security and other new technologies that are revolutionizing the power industry.
Credits: 3 Credits
Course Delivery: Through online.
Course Web Page: All course handouts (e.g., syllabus, problem sets and solutions, lecture notes, lecture reference material, exam solutions, etc.) will be posted to https://elearning.uwf.edu.

Prereq/Correq : EEL3111- Electric Circuits-1.

Topics covered:

1) Concept of power plant efficiency and the implications for Co_2 emission impacts and appreciate the differences among main power plant variations,
2) Classical economic evaluation of power plant worth for energy and capacity (power), Concept of "levelized cost of energy" and how this tool can be used to evaluate and compare traditional coal or hydro with new solar or wind energy resource options ,
3) Basic distributed energy resources elements and how these "demand side" resources work to benefit the grid ,
4) Overview of renewable energy sources, smart devices for smart grids (inverters, meters, home area networks etc.),
5) Current state of US power grid with examples of blackouts and brown outs,
6) Examples of small residential grid connected system and large scale grid connected plants,
7) Micro grids (residential and commercial scale) architecture, planning, centralized management and budgeting, Microgrids Vs macrogrids, network management service,
8) Tradeoffs between centralized versus distributed systems, overviews of current topologies,
Challenges of local power generation (connection to the grid, dynamic loads, storage, power production deficit or over planning),
9) Emerging microgrid test bed examples, examples of demand side and load management, power line and other signaling approaches for flexible tariff scheduling of generation and load pattern,
10) Overview of current storage technologies, Storage integration into grid at various levels (small, medium and large-scales),
11) Electrification of transportation by means of plug in electric vehicles, G2V and V2G technologies and smart grid bi directional communication for sending price signal,
12) PSCAD modeling of smart grid with renewable energy sources,
13) Stability and control of smart grid,
14) Cyber security and protection aspects of smart grid
15) Green building concept- Energy management options- energy auditing and energy targeting, Energy efficiency of buildings

Textbook:

1) **Principles of Sustainable Energy Systems, Second Edition,** Frank Kreith, Susan Krumdieck., Mechanical and Aerospace Engineering Series , August 19, 2013 by CRC Press. ISBN 9781466556966 - CAT# K15449
2) **Sustainable Energy: Choosing Among Options-** Jefferson W. Tester, Elisabeth M. Drake ,Michael J. Driscoll ,Michael W. Golay and William A. Peters, The MIT Press; Second Edition (September 28, 2012), ISBN-10: 0262017474 , ISBN-13: 978-0262017473.

Course outcomes:

1) Understand and evaluate alternative modes of energy supply and their interplay, including renewable, fossil-fuelled and nuclear-based supply.
2) Recognize the physics of environmental issues, including greenhouse effect and global climate change.
3) Quantify current energy supplies and demands. Learn and appreciate the importance of geopolitical/social context in sustainability analysis.
4) Describe integration of intermittent renewable electricity into grid system and compare the efficiency of different energy storage solutions (e.g., batteries, fuel cell and hydrogen storage).
5) Solve simulation problems by designing and developing microgrids for residential, commercial and industrial communities.
6) Demonstrate an understanding of Smart Grid, electric transportation and smart building concepts and correlate these concepts to real life scenarios.
7) Complete a comprehensive design project, working in teams of two students each, that involves both oral and written communication of results.

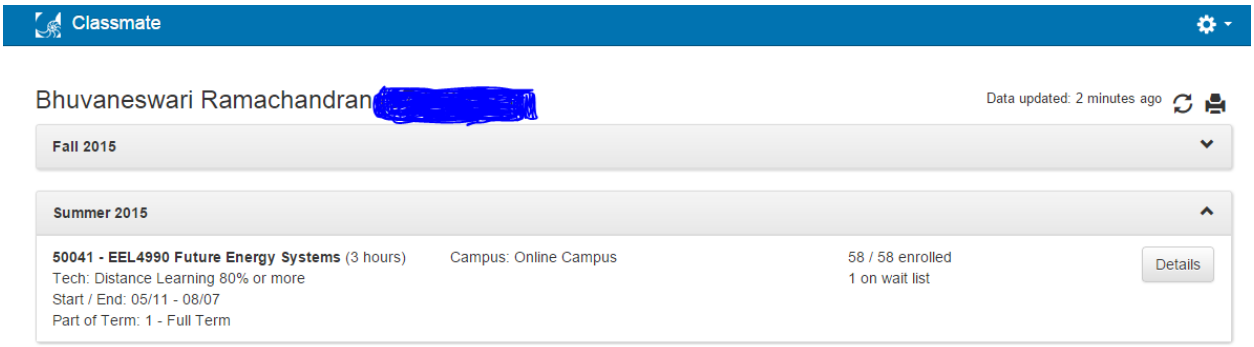
Grading:
Online test-1: 20 points
Online test-2- 20 points
Design project: 10 points
Final Exam: 50 Points

Grading Scale:

93+	≤	A	≤	100
90+	≤	A−	≤	93−
87+	≤	B+	≤	90−
83+	≤	B	≤	87−
80+	≤	B−	≤	83−
75+	≤	C+	≤	80−
70+	≤	C	≤	75−
65+	≤	D+	≤	70−
60+	≤	D	≤	65−
0	≤	F	≤	60−

Note that a grade of incomplete (I) will only be issued to a student if all requirements stated in the UWF undergraduate catalog have been met. See http://catalog.uwf.edu/undergraduate/academicpolicies/grades/#gradesofincomplete.

I have also attached a snapshot of e-learning site at our university to indicate the level of interest displayed by students towards this specialization. We had originally set the maximum number of students to 45. But due to the huge interest shown by students, we increased the number of seats to 58 and there is still 1 more student on waiting list hoping to register himself for this course.



We in the Electrical and Computer Engineering department at UWF, recently confirmed a study abroad partnership with a leading University in France (INSA, Lyon). A bilateral agreement has been signed between the two institutions that paves way for student exchange for study as well as faculty collaboration for research. We expect this study abroad program to bring more interested students into the specialization. Since I have a grader to evaluate the tests and projects, we have set a maximum limit of 60 students for this summer course.

Solar Energy Technologies: Fundamentals and Applications in Buildings

PI: Cheng-Xian (Charlie) Lin, Ph.D., Associate Professor, Department of Mechanical and Materials Engineering, Florida International University

Project Description

This project develops a new online course in solar energy technologies, with emphasis on solar applications in buildings, taking account the unique solar resource and infrastructure in the state of Florida. The course will be offered completely online through the Blackboard Learn system. The course targets senior undergraduate students and entry level graduate students who study in FIU as well as other universities in the state of Florida. The course will be offered at least once a year. Students will earn 3 credit hours by taking the course in the Spring, Fall, and/or Summer semesters.

Summary

During this reporting period, the following progress has been made toward the offering of a new online course in solar energy at Florida International University:

Course listed in university's catalog

- The new course has been officially approved the University Curriculum Committee at Florida International University.
- The course number assigned to the course will be EML 4416. Formal notice was received on June 09, 2015.
- The new course has been listed in FIU's 2015-2015 catalog for undergraduate students. The course description in the catalog is as following:

EML 4416 Solar Energy Technology: Fundamentals and Applications (3). Principles of solar energy conversion, BIPV systems, solar thermal systems - air and water collectors, solar assisted air conditional systems. Prerequisite: EGN 3343.

Teaching material development

- The PI has collected and evaluated all the necessary teaching materials to be used for the course.

- The PI is in the process of finalizing the specific subjects to be covered in each chapter of the course. The chapters to be included in the course will include:

Chapter 1. Introduction;
Chapter 2. Solar Irradiation;
Chapter 3. Principles of Solar Energy Conversion;
Chapter 4. Integration of Solar systems in Buildings;
Chapter 5. Solar Thermal Systems: Water Collectors;
Chapter 6. Solar Thermal Systems: Air Collectors;
Chapter 7. Hybrid Solar Energy Systems;
Chapter 8. Solar Cooling Systems for Air Conditioning.

Online course implementation

- The online course has been scheduled to be offered in Spring 2016 at FIU.
- A course shell has been created for this course in the Blackboard teaching system.
- In the next few weeks, the PI will work the staff in the FIU Online department to design and upload the online course materials per the university's procedures.

1. Funds leveraged/new partnerships created
    1. The PI is exploring how to leverage the FESC funds for new collaborations or proposals.

2. The PI is also planning to write a conference paper based on the online course's implementation and outcome.

A Certificate Program to Enhance Sustainable Behavior Change Competencies for Educational Outreach Professionals

PI: Laura A. Sanagorski Warner, Ed.D. , Assistant Professor, Department of Agricultural Education and Communication, Center for Landscape Conservation and Ecology, University of Florida/IFAS

Project Description: This project supports the development of a certificate program targeting Extension and other educational professionals who conduct outreach education to encourage energy conservation. The aim of this program is to improve the process of program delivery and ultimately increase the adoption of energy-conserving behaviors among participants' clients. This project is important because people need to change their behaviors to overcome environmental challenges. A major focus of this program is program development and delivery incorporating principles of *social marketing*, the application of traditional marketing principles to programs that encourage behavior change that benefits individuals and the communities in which they live. This certificate program has the potential to reach the thousands of individuals who are taught by participants.

Progress Summary: During the current reporting period, the materials for eight modules were completed and delivered to the instructional design team. Prior to delivering the modules we piloted the educational materials with a University of Florida Sustainability and the Built Environment class. Feedback and edits from the students were subsequently incorporated into final drafts of the modules. The instructional design team is currently working on building the online course. Three presentations were given during this reporting period resulting in a list of approximately 50 individuals who are interested in signing up for the course once it goes live.

We faced an unanticipated challenge that emerged in January. At the time we created the budget for our project proposal, University of Florida's Distance and Continuing Education (DCE), the project's design team did not charge for development and delivery of online, non-credit certificate programs. Therefore we did not request funds for this part of the project. DCE reorganized and changed several procedures, and informed us that there now is a charge for these services. The PI and Co-PI were able to secure funding for building the online program, which was generously provided by the UF Department of Agricultural Education and Communication. Once this issue was resolved, project design moved forward after a slight delay.

We are very pleased to report that the certificate program and corresponding mini-grant program are now live. Both are accessible online (http://gardeningsolutions.ifas.ufl.edu/clce/socialmarketing/).

Specific milestones are detailed below:

October 2014:

- Project awarded
- Began meeting with UF instructional designers

November 2014 - December 2014

- Certificate program module design
- Pilot tested paper-based certificate program with Students (n = 12) enrolled in UF Practicum in Sustainability and the Built Environment (DCP 4941/DCP 6931) class
- Gave a presentation on this forthcoming program at UF In-service training: *Pharmaceuticals and Personal Care Products (PPCPs)*

January 2015 - February 2015

- Module revision with student feedback into final program components
- Ongoing meetings with instructional designers

March 2015

- Instructional designers delivered the framework for the forthcoming program
- Instructional design ongoing
- Submitted abstract and poster proposal to annual FESC conference

April 2015

- Presented a poster on this program at the Department of Agricultural Education and Communication Research and Extension Symposium
- Gave a presentation on this program at UF In-service training: *The Sustainable Floridians Program: From Soup to Nuts*
- Instructional design ongoing

May – June

- Video recordings for course lectures completed
- Final certificate program delivered

July – August

- Website development
- Soft launch of certificate program
- Mini-grant program application development
- Development of promotional materials

September

- Publicity for certificate program, broader advertising activities
- Personally distributed 150 flyers to potential participants
- Direct mailing to 500 outreach organizations
- Course enrollment began
- Launch of minigrant program

To date, 11 individuals have earned the *Certificate in Cultivating Change*. There are an additional eight individuals currently enrolled and in-process. In the upcoming months, we will continue to promote the program, conduct evaluation activities, and administer the mini-grant stipend program.

Funds leveraged/new partnerships created

FESC funds have been leveraged by using students and staff to pilot and review the educational materials.

New collaborations		
Partner name	Title or short description of the collaboration	Funding, if applicable
UF Center for Landscape Conservation and Ecology	Staff donated in-kind time to develop website launch page for both certificate program and mini-grant application	In-kind

UF Department of Agricultural Education and Communication	Staff donated in-kind time to develop promotional materials	In-kind
Florida Office of Energy (John Leeds)	Has a listserv that will be used to advertise the program	
Florida Association of Museums	Has a web site that will be used to advertise the program	
League of Environmental Educators in Florida	Has a listserv that will be used to advertise the program	

Grants Awarded					
Title	Agency	Reference Number	PI, Co-investigators and collaborators	Period of Performance	Funding awarded
A Certificate Program to Enhance Sustainable Behavior Change Competencies for Energy-Focused Educational Outreach Professionals	University of Florida	Award # 00071381	Laura Warner, PI Kathryn Stofer, CO-PI	November 2014 - March 2015	$18,102.26

Educational Modules in Support of Sustainable Energy Courses

PI: Juan C. Ordonez, Associate Professor of Mechanical Engineering, FAMU-FSU College of Engineering, Energy and Sustainability Center (Director), Center for Advanced Power Systems, Florida State University

Project Description: A series of educational modules on sustainable energy are proposed. The modules will be incorporated initially into existing courses in sustainable energy, thermal fluids and senior design at the FAMU-FSU College of Engineering and later components will be used in non-engineering courses on sustainable energy. The period of performance of this proposal is one year, and during this time modules and supporting material will be developed. The departments and centers involved are committed to give continuity to this effort. The midterm goal is that what is initiated in this project will progress towards a collection of modules that can be assemble into self-standing online courses with hundreds of students as well as hand-picked material to support courses in the energy field. The proposed modules emphasize on real systems and devices to elaborate on relevant aspects of sustainable energy, differing in this way from available online course material. In particular, we propose to develop the modules around FSU's Off-Grid Zero Emissions Building (OGZEB), designed by FSU's Energy and Sustainability Center (ESC) to serve as an energy efficient prototype for developing and testing cutting edge, sustainable energy technologies in both residential and commercial settings. The modules will refer to the OGZEB and use its systems to illustrate different concepts. This will provide continuity to the material, and motivate students through exposure to concrete systems.

Executive Summary

A series of educational modules on sustainable energy are developed in this project. These modules are being incorporated into ongoing classes on sustainable energy at the FAMU-FSU College of Engineering and it is expected that they will be later integrated into additional courses in thermal fluids, senior design, as well as non-engineering courses on energy. The midterm goal is that what is initiated in this project will progress towards a collection of modules that can be assembled into self-standing online courses with hundreds of students as well as hand-picked material to support courses in the energy field.

The modules emphasize on real systems and devices to elaborate on relevant aspects of sustainable energy, differing in this way from available online course material. In particular, the modules are developed around FSU's Off-Grid Zero Emissions Building (OGZEB) and topics relevant to it and its subsystems. The OGZEB was designed by FSU's Energy and Sustainability Center (ESC) to serve as an energy efficient prototype for developing and testing cutting edge, sustainable energy technologies in both residential and commercial settings. The reference to the OGZEB subsystems will provide continuity to the material, and motivate students through exposure to concrete examples.

The initial courses impacted by the modules are listed in Table I. These courses are currently taught by the PI and co-PI.

Table I. Courses in which modules will be used and target audience.

Course	Typical audience	Typical enrolment
EML 4450/5451 Energy Conversion Systems for Sustainability	Undergraduate and graduate in engineering and science	40
EML 4452 4452/5453, Sustainable Power Generation	Undergraduate and graduate in engineering and science	40
EEL 4280/ 5285 – Renewable Energy I	Undergraduate and graduate in engineering and science	30

In order to track progress, it was decided by FESC to conduct this project in two phases. Phase I (being reported here) consisting on modules covering material on solar photovoltaic and biofuels from microalgae as illustrated in Table II. Phase II will include additional modules covering energy storage, HVAC and residential energy use in the context of the Off-grid Zero Emissions Building.

Table II. Phase I modules topics

Module	Topics
Solar Photovoltaic	Solar resources *OGZEB -solar irradiance measurements (pyrheliometer and pyranometer). Semiconductors Solar cells Solar tracking *Solar tracking lab demo at the OGZEB Power converters for photovoltaic systems *Demo of PV converters used in the OGZEB. Current and future outlook
Biofuels from Microalgae	Introduction, algae strands, oil content, current status Algae productivity, biofuel potential? Methods of cultivation Methods of extraction Current research efforts (e.g. hydrogen production from microalgae, and compact photobioreactors) *ESC microalgae cultivation

(*) Refers to a module that makes use of materials/supplies

Goals and Objectives:

The goal/objective of this project is to develop educational modules that will be useful to students and instructors in classes covering topics in energy and sustainability.

Project Activities, Results and Accomplishments:

The educational modules development has been approached in three fronts:

- Lectures: Archiving and development of lecture material.
    - Sustainable Energy Background
    - Solar Strategy
    - Solar Radiation
    - Solar Electricity
    - Fuel and biomass from Microalgae
- Videos:
    - General video on OGZEB and OGZEB energy systems
    - Solar irradiance
    - Use of a pyrheliometer and pyranometer for solar measurements
    - Solar simulator
    - Solar tracking
    - Current and future electric grid
    - Renewable energy power flow control
    - PV array modeling
    - MPPT Technology
    - Grid-connected PV Generation System
    - Energy storage for Renewable Energy System including Lithium-ion battery, Ultracapacitor and Fuel Cells
    - Microalgae cultivation in a laboratory setup
    - Large scale cultivation of microalgae – tubular photo-bioreactors.

- Laboratories/Homework/ Sample calculations:
    - A design example to size a battery for a residential PV house using a physical battery lifetime model
    - Data set and laboratory handout to use in connection with solar irradiance data obtained with pyrheliometer and pyranometer in Tallahassee, FL.
    - Instructions and handout on sizing OGZEB PV system using NREL System Advisory Model.

Materials and supplies from this effort where critical in upgrading infrastructure at FSU that allowed preparation of material for the educational modules.

a. A new set of lights for ESC solar simulator allows for reproduction of solar irradiation conditions in an indoor environment. A video explaining the technical details of the solar simulator, including its operation and characterization is included in the modules. In addition, data from the simulator is being integrated into online homework and other student activities.

Figure 1- ESC solar simulator

b. A video explaining solar irradiance measurements (pyrheliometer and pyranometer) has been produced. Datasets from different days are being made available for students used as part of design exercises.

Figure 2- Student explaining operation of solar pyrheliometer.

c. OGZEB energy storage system has been upgraded and will be incorporated into the videos.

Figure 3- OGZEB battery storage system (two 48 V-battery arrays in parallel)

Concluding Remarks

In the next reporting period we will present a web portal in which the modules will be maintained and specific plans for phase II.

Publications

- Thermoeconomic Analysis of a Solar Thermal System in an Off-Grid Zero Emissions Building (in preparation for ASME Power and Energy)
- Educational modules in support of sustainable energy courses, in preparation for American Society for Engineering Education in New Orleans, LA for the 123rd Annual Conference & Exposition! June 26 - 29, 2016.

Renewable Energies and Sustainability Education

CO-PI's: Dr. Ryan Integlia, Electrical and Computer Engineering, Florida Polytechnic University and Dr. Sesha Srinivasan, Physics/Innovation and Technology, Florida Polytechnic University

Team Participants:
Mr. Gary Albarelli, Florida Industrial and Phosphate Research
Dr. Brian Birky, Florida Industrial and Phosphate Research
Dr. Jorge Vargas, Electrical and Computer Engineering
Dr. Jaspreet Dhau, Chemistry and Business

Project Period: October 01, 2014-September 30, 2015

Summary: This FESC education proposal is aimed at developing a stand-alone course content accessibility, conducting competitions and workshop that can be offered to undergraduate and graduate students at the Florida Polytechnic University as an elective. The related course materials would be available and accessible by the general public and may provide added awareness and public outreach. This work will be aligned with the renewable energy and sustainability initiatives at the University. This course will create awareness and engagement of various renewable energy systems, technologies promoting sustainable, and economic development concepts supporting entrepreneurship among students and industry (Mosaic and others) that impacts the workforce and the economy of Florida.

Course Preparation (EEL 3287): The proposed course "Renewable Energy Systems and Sustainability" (EEL 3287) is officially approved by the Program Coordinator of Electrical Engineering and will be offered in spring 2016 semester. 10 students have shown interest in signing up in the course. The syllabi and other logistics of implementing this course with successful learning outcome are currently underway.

Progress in the Project Period: The team participants of this FESC project involved during the past summer 2015 to create STEM innovation teaching labs and FL Poly Open Access Journal projects which are very relevant with a focus to Renewable Energy and Sustainability Education. We have created students' interests that emerges out to be a success in students' organized Sustainability competitions at Florida Polytechnic University. Some of our faculty and students progresses and accomplishments are listed below:

a. **EEL 3287 Renewable Energy and Sustainability course** is now in Florida Polytechnic University's spring 2016 course offering schedule and the course preparations mentioned above are in progress.
b. Drs. Srinivasan, Integlia and Vargas attended an ASEE workshop on National Effectiveness Teaching Institute (NETI-1) at Montreal, Canada. This workshop was focused on active learning skills, flipped models and inductive learning methodologies which eventually integrated into our FESC project course.
c. Dr. Dhau spearheaded and developed first FL Poly Open Access Journal which will be focused on bringing out scientific contributions from our faculty, students and staff and it will be open to other institutions as well. The first issue will be planned for March 2016 and the teaser first article is

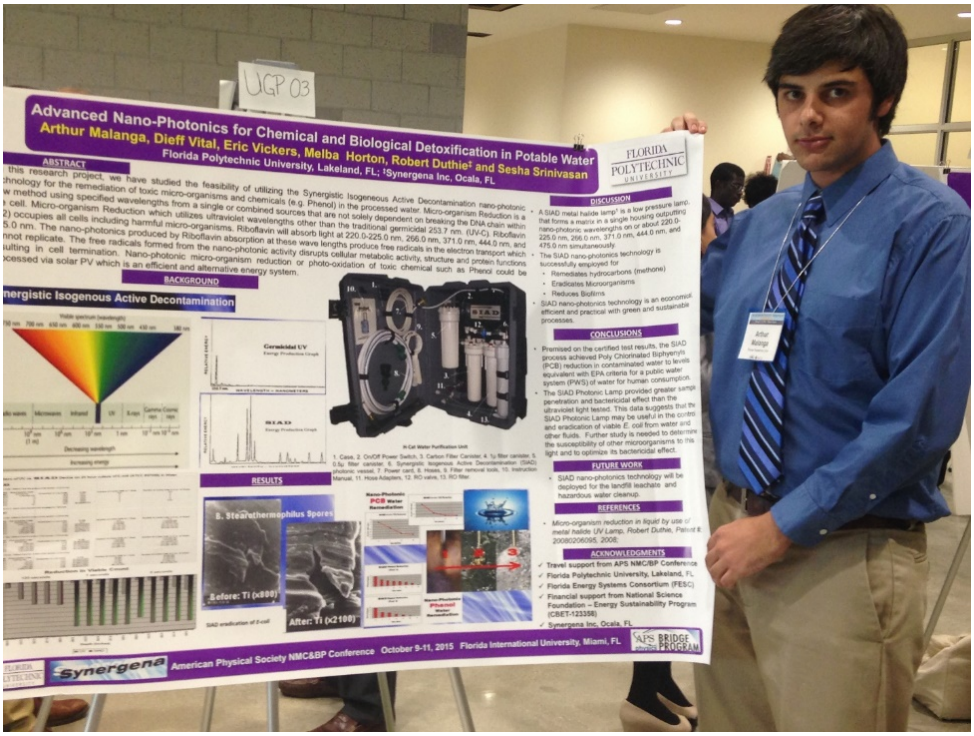
planned to be published in December 2015. This Open Access journal is a theme based and is currently focused on "Sustainability"

d. Drs. Integlia, Srinivasan and Horton have attended and also their undergraduate students presented the research posters at the recently held Hinckley Center Colloquium on Solid Waste Management. Graduate and undergraduate students Joe Prine, Arthur Malanga and Dieff Vital have presented their research on sustainability in 3D Printing, water remediation technologies.
e. Student sustainability competitions activities have begun with the involvement of undergraduate student Mark Glaser and the Student Governing Body's Sustainability Committee chaired by Mark Glaser and advised by Nicolete Hickmen, Sesha Srinivasan, Jaspreet Dhau and Ryan Integlia.
f. Student engagement activities to monitor building efficiency spearheaded by Mark Glaser and the Sustainability Committee with support of Dr. Hickmen.
g. Drs. Srinivasan and undergraduate students Eric Vickers, Arthur Malanga, Dieff Vital have attend American Physical Society meeting on National Mentoring Community and Bridge Program. Travel fund was sponsored by the APS for all.
h. Dr. Srinivasan has presented his research poster at the Gordon Research Conference at Stonehill College. The title of this research was with the FESC project.
i. The Florida Polytechnic University's 2nd Annual Industry summit was held in February 2015, where an exclusive session was organized by this FESC and FIPR team on "Sustainability". Number of private industry partners and collaborations have been established to foster the sustainability initiatives. Some of these companies include Mosaic, Underground Imaging, Chastain-Skillman, Stryker, Green Technologies LLC, Amec Foster Wheeler, Synergena, Spin Magnetics, JACO and others.
j. JACO is exploring Sustainable Advanced Manufacturing projects with graduate and undergraduate students in conjunction with FESC
k. Mobile Environmental Monitoring Infrastructure project has begun through multi university collaboration and industry support involving students
l. Lakeland Electric and JACO has agreed to participate with the support of guest lectures and internship opportunities.
m. Undergraduate student Eric Vickers has been selected as a Presidential Ambassador of Florida Polytechnic University. Eric is doing his research with Dr. Srinivasan. He has also secured his internship and currently doing his internship at Ocean Optics.
n. A collaborative NSF-REU proposal on Sustainability has been submitted which comprises the faculty across the colleges and disciplines, science, engineering, information and technology. This NSF-REU proposal can serve as a springboard for attracting students to the FESC EEL 3287 course.
o. FL Poly students is involved in Sustainability competitions which is organized by one of the students Mark Glaser. 11 teams have submitted their research proposals based on the EPA's P3 formulations which will be reviewed by the team of judges from faculty and FIPR scientist pool. The deadline of submission is completed, and judges will announce their review comments by November 2015. Students then will start building the project based on a budget up to $1500 set forth for the educational fund. The winning team will be announced in April 2016 and also this team members will receive financial assistance from Florida Industrial Phosphate Research Institute and Florida Polytechnic University.
p. Students (past or present) supported by the project, and the degree sought or attained: Joseph Prine (Graduate Student); James Mulharan; Eric Vickers; Arthur Malanga; Dieff Vital (Undergraduate Students).
q. External collaborators: Clean Energy Research Center - University of South Florida, Princeton University, Synergena Inc, IVHCO
r. Drs. Srinivasan and Dhau have responded to the ARPA-E whitepaper submission on technologies related to thermochemical storage and self-healing membranes.
s. Dr. Integlia have established industrial collaborations with Quantum Leap Farm, Tri-Vector and Harris Corporation. Dr. Integlia also secured $30K for an educational training project from Harris the past summer 2015.

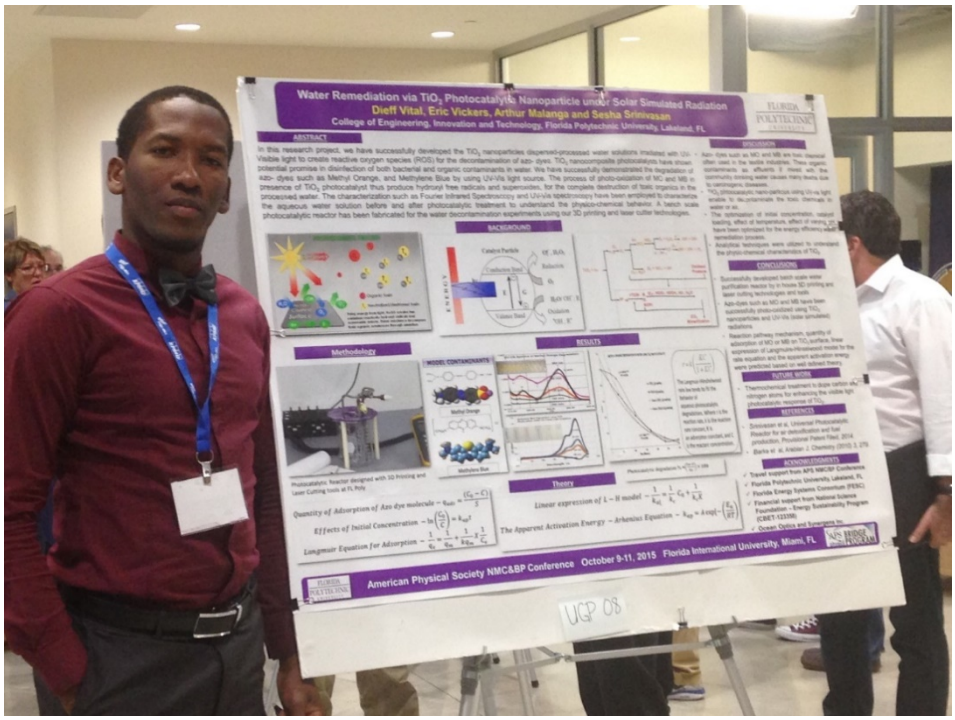
t. Graduate student Adam Schuster was involved with designing active learning curriculum presentation as part of the summer education study with Drs. Srinivasan, Integlia and Vargas. Adam may choose his Master's thesis on the Engineering the Engineering Education and will work with the team for FESC education course implementation at FL Poly University.
u. Earth Day workshops and seminars on Sustainability and Renewable Energy have been conducted at the FL Poly Florida Solar Energy Center. Director Bob Ready was an invited speaker.
v. Involvement in summer programs supporting sustainability and renewable energy such as MERIT and FIPRI Summer Programs at Florida Polytechnic University.
w. Drs. Dhau and Srinivasan are currently engaged in Poly Premier Lectures and course materials presentation video capturing for posting to the online users. This activity is ongoing and is currently executed with the FL Poly's Cyber Gaming and Media Lab. Once the FESC funded EEL 3287 course is offered in Spring 16, the co-PIs will extend the online podcasting (virtual academy) with the available facilities at FL Poly.
x. Dr. Srinivasan has delivered his virtual presentation on Hydrogen Challenges in "on board fuel cells" as part of the Indo-US Center for Engineering Education (IUCEE) and about 50 Professors and faculty attended this virtual presentation from Indian Universities.
y. Drs. Integlia, Vargas and Srinivasan have attended the Grants Conference in Tampa, FL which was hosted by National Science Foundation, June 1-2, 2015.

Photos of events where the Co-PIs and their students participated:

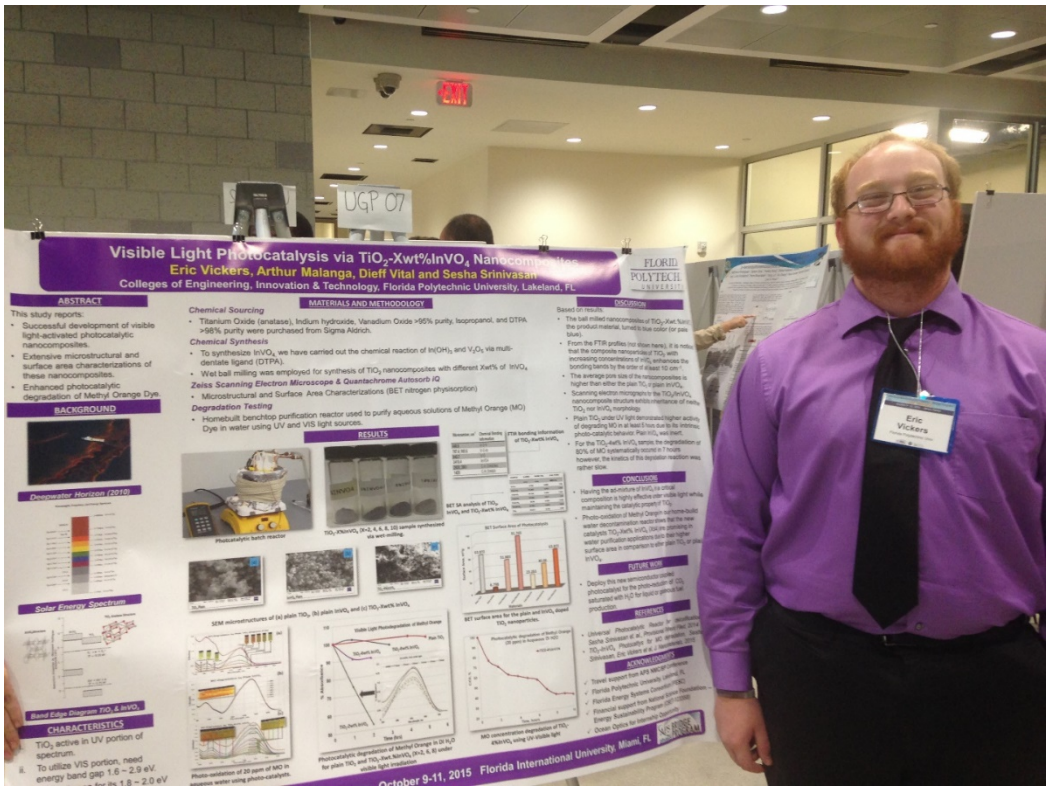
FL Poly students Eric Vickers, Arthur Malanga and Dieff Vita with faculty Dr. Sesha Srinivasan at the 2015 American Physical Society Meeting, Florida International University, Miami, FL.



Arthur Malanga, FL Poly student with his research poster presented at the 2015 APS Meeting



Dieff Vital, FL Poly student with his research poster presented at the 2015 APS Meeting

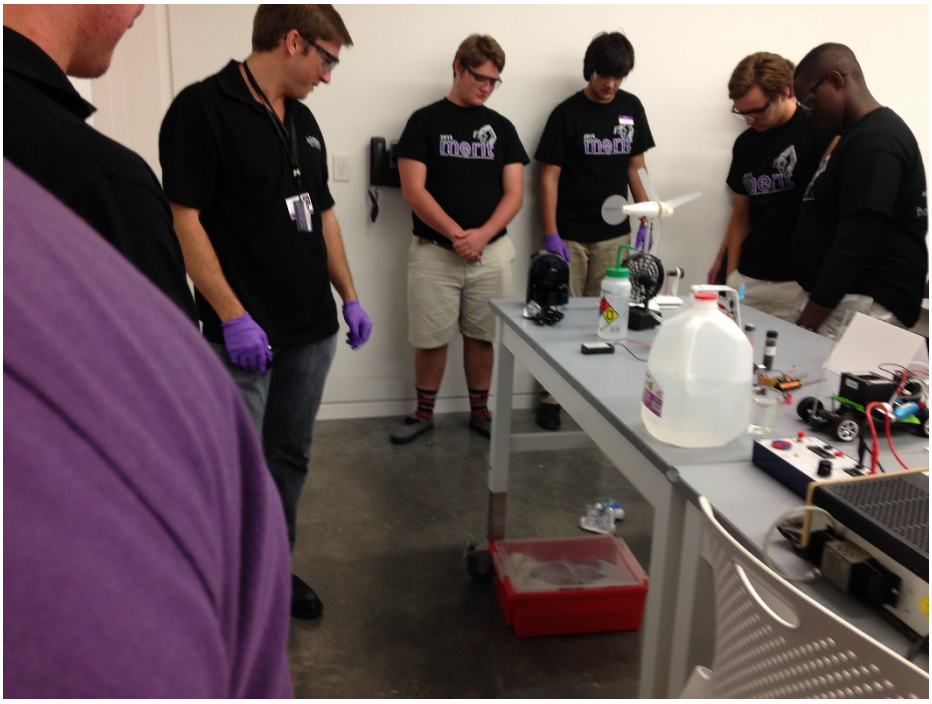


Eric Vickers, FL Poly student with his research poster presented at the 2015 APS Meeting

FL Poly faculty and students' team at their poster on "Water remediation via nanophotonics and solar PV assisted Photocatalysis"

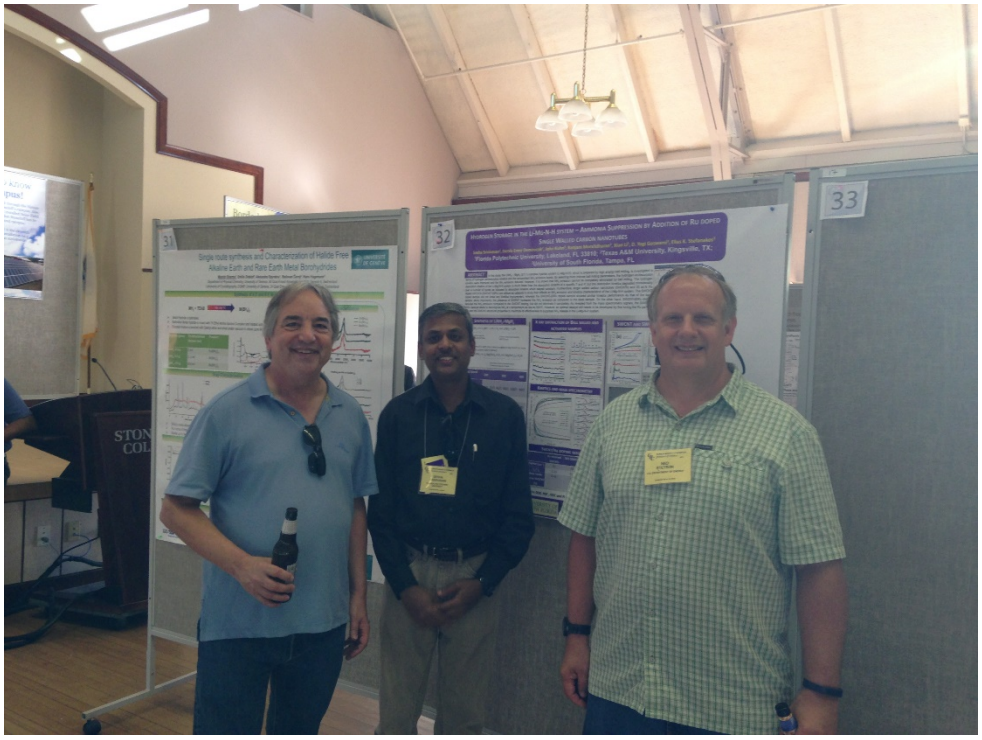
FL Poly faculty and students' team at their poster on "Sustainable Advanced Manufacturing"

FL Poly faculty, Drs. Jorge Vargas, Sesha Srinivasan and Ryan Integlia with Dr. Michael Prince (Bucknell University), one of the facilitators of National Effective Teaching Institute (NETI) sponsored by the American Society of Engineering Education (ASEE), Montreal, Canada, July 29-31, 2015. FL Poly faculty were participated in the three day workshop on innovative teaching and active learning.



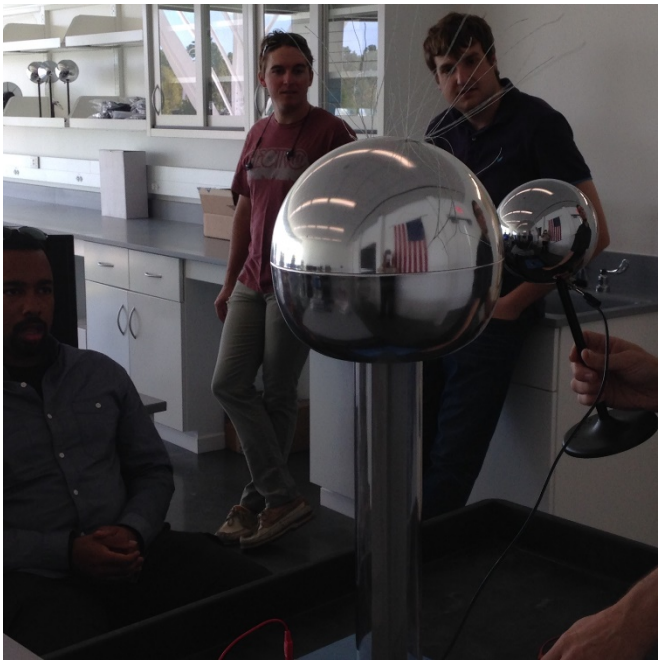
FL Poly EE student James Mulharan demonstrating the renewable energy and fuel cell technologies to MERIT 2015 participants (Summer 2015)

FL Poly student Max Farrell demonstrating the Cyber Gaming and Media Lab capabilities to FIPR Institute's Summer Outreach 2015 participants (Summer 2015)



FL Poly faculty Dr. Srinivasan presenting his research poster to the Program Director and his Post-Doctoral Advisor at the GRC 20015 meeting at Stonehill College, MA.

FL Poly-FIPR Summer 2015 students' (K-8) camp was organized at FIPR Institute. Ms. Indira Sukhraj and Ms. Kate Beamon are facilitating student's projects on renewable energy and sustainability.



FL Poly Physics Club students demonstrating the Electrostatic Charges experiment using Van de Graff Generator

OUTREACH

FESC outreach program leverages the existing network of UF extension offices to reach out to each of our communities. The Florida Cooperative Extension Service has experience developing and delivering educational programs and products related to energy and resource-efficient community development with emphasis on housing. These programs and products include targeted continuing education courses for licensed builders, architects, engineers, landscape architects, interior designers, and others. Also, the UF Program for Resource Efficient Communities is an interdisciplinary group that promotes the adoption of best design, construction, and management practices in new residential master planned developments.

The goal of the program is to develop educational outreach programs and materials designed to deliver practical, applicable information and knowledge on energy-related topics to the general public as well as targeted to specific audiences such as builders, planners, engineers, architects, small businesses, local governments, and utilities through the Cooperative Extension Service and others. By focusing educational programming on climate and efficient use of energy and water, the program aims to provide the knowledge needed by building and energy professionals, local governments, and the general public, to significantly reduce greenhouse gas emissions in Florida.

Outreach Team Members:
PI: Dr. Pierce Jones, Director, Program for Resource Efficient Communities (PREC)
Co-PI's:

- *Dr. Kathleen C. Ruppert*
- *Ms. Barbara Haldeman,*
- *Ms. Lynn Jarrett, Mr.*
- *Lesly Jerome,*
- *Mr. Hal Knowles,*
- *Mr. Craig Miller,*
- *Ms. Jennison Kipp Searcy, Ms. Christine Swanson,*
- *Mr. Nicholas Taylor*

FESC provided new funding to the outreach group to continue with their Sustainable Floridian^{SM} Program. During this project's time period, 41 fact sheets were updated from their prior versions and 16 new fact sheets were added. All the fact sheets were posted at the FESC web site (http://www.floridaenergy.ufl.edu/public-outreach/energy-fact-sheets/) and also at FDACS' My Florida Home Energy site. The final outreach report is given as an attachment to the annual report. The executive summary from the final report is given below:

Sustainable Floridians^{SM} Program, By Kathleen C. Ruppert (kr@ufl.edu)

Executive Summary
The Sustainable FloridiansSM program, initially funded by an American Recovery and Reinvestment Act (ARRA) grant, is an education/community development program offered through county Extension offices. It was developed in the Department of Family, Youth, and Community Sciences with cooperation and technical assistance of the UF/IFAS Program for Resource Efficient Communities (PREC), with financial support and consulting assistance from the Florida Energy Systems Consortium (FESC), the UF Office of Sustainability, and with assistance in curriculum development from county faculty.

The program was piloted in Leon and Marion counties in 2010 to meet an objective of "bringing sustainability home" in keeping with the UF/IFAS Extension statewide goal for 2008-2012: "Sustainable Living: Maintain, enhance, and establish sustainable communities." Pinellas County soon joined in offering the program. Osceola and Sarasota counties began their programs in 2012; Brevard in 2014; and Monroe in 2015. Other counties considering offering the program in the not too distant future include Palm Beach, Polk, Santa Rosa, Seminole, and Volusia.

The program is relevant to the Extension Service's role in providing research-based, geographically appropriate information and organizing capacity to improve the economic, environmental, and social sustainability of Florida communities. This program teaches Floridians how to make wise use of natural resources, which in turn helps to make households and communities more resilient and financially sound. In addition, the program offers leadership training for participating citizens to take part in community service and education projects through Extension offices. The Sustainable FloridiansSM program connects people through an engaging curriculum, which can be applied in both urban and rural counties, with the goal of creating a cadre of engaged, educated citizens supported by FESC and UF/IFAS resources relating to energy/water/sustainability.

In order to support the Sustainable FloridiansSM (SF) program a number of fact sheets needed to be updated or written on energy and climate-related topics. In conjunction with input from FESC, the team of authors/editors decided that it would be in the user's best interest if all of the fact sheets were accessible from a single website so it was agreed that the Florida Department of Agriculture and Consumer Services (FDACS) My Florida Home Energy (MFHE) website (http://www.myfloridahomeenergy.com) would be the library's website host. The publications are under one of 12 topic headings: Appliances and Electronics, Choices to Save Resources, Contractors and Certifications, Energy Supply and Services, Financing and Incentives, Lighting, Our Carbon Challenge, Research Highlights, Space Conditioning (HVAC), Transportation, Water: Indoors and Outdoors, and Weatherization at Home. In this way, the fact sheets can be viewed with both desktop computers and mobile devices and can be printed or shared via social media from the action bar at the top right of each fact sheet page.

During this project's time period, 41 fact sheets were updated from their prior versions and 16 new fact sheets were added. All 57 fact sheets now contain live links to additional information with some being considerably more interactive (e.g., Whole House Improvements) with improved multimedia content (e.g., embedded videos) and click through URLs to expanded content
(e.g., US DOE infographics). Where applicable, real-time streaming APIs listing
ENERGY STAR® Certified Products have been embedded near the end of relevant fact sheets
(e.g., Refrigerators and Freezers).
The SF program was further supported through: updating four of the PowerPoint presentations; developing three new PowerPoint presentations; re-writing the Course Leader's Handbook; offering the program for the first time in two new counties – Brevard and Monroe; updating and maintaining the SharePoint site; maintaining and periodically meeting with the Sustainable FloridiansSM Advisory Committee; organizing and facilitating a two day in-service training (IST); meeting with county faculty around the state to explain/describe the program; updating/maintaining an email list of county faculty interested in learning more about the Sustainable FloridiansSM program, FESC and energy related topics

Other Outreach Activities

FESC Web Site and e-Newsletter (www.FloridaEnergy.ufl.edu)

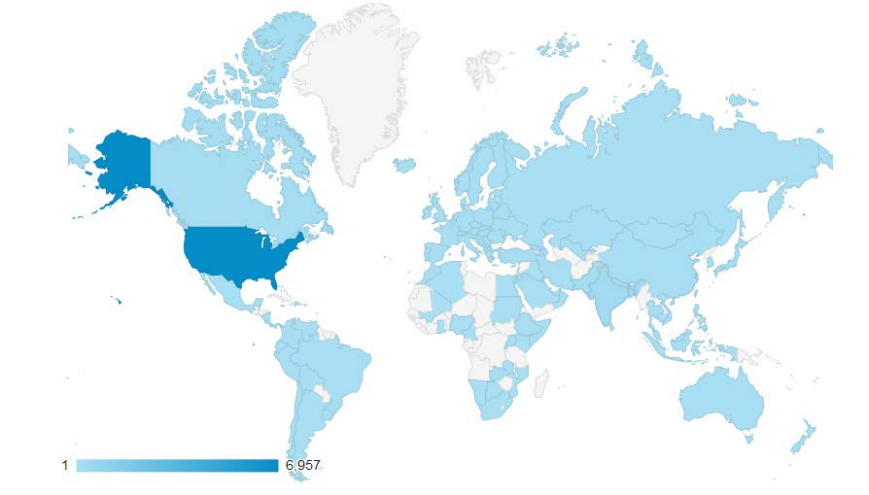
FESC Website: FESC Website and e-Newsletter: The FESC website continues to be an important communication tool for our program. It is updated regularly to remain current and to better serve our users. Based on a Google Analytics report, the FESC web site was viewed by 12,652 Google visitors during the period of October 1, 2014 through September 30, 2015. The viewers visited 43,338 pages. Viewers were from over 131 countries, including those in North and South America, Europe, Asia, Australia, the Middle East and Africa.

The data compiled from Google Analytics are given below:

Activity overview of the FESC's website from October 1, 2014 through September 30, 2015.

Activity	10/1/2014 – 9/30/2015
Total Visitors	12,652
Page Views	43,338

FESC Website Visits by Country



FESC e-Newsletter: Seven e-newsletter were distributed during the reporting period. FESC office prepares and distributes electronic newsletter highlighting SUS faculty accomplishments. In addition, we provide worldwide and nationwide energy news. The newsletters are distributed to over 1000 contacts. The printable version of the e-newsletters are posted at http://www.floridaenergy.ufl.edu/publications/fesc-newsletters/.

FESC Feb 2-3, 2015 Workshop, Orlando FL

The 2015 FESC Workshop entitled "Integration of Renewable Energy into the Grid" was held on February 2 - 3, 2015 at the Hyatt Regency Orlando Hotel in Orlando, FL. This instructional workshop was designed for industrial personnel, students and faculty who wanted to learn the state of the art and future directions in enabling renewable energy integration. A total of 114 people were in attendance; 66 university faculty and students, and 48 industry members. Experts in this area presented the workshop lectures.

The invited speakers and the title of their presentations are given below:

- Sonja Glavaski, US Department of Energy: **Power Grid of the Future**
- Sila Kiliccote, Lawrence Berkeley National Laboratory: **Load as a Resource: Examples from Field Tests**
- David Sun, Chief Scientist for the Network Management Solutions of Alstom Grid: **DER Integration – A Driver for the New Phase of Utility Industry Transformation**
- Kathleen O'Brien, GE Global Research: **Renewable Integration: An Industrial R&D Perspective**
- Xiaoming Feng, Ph.D., Corporate Research Fellow at ABB: **Power Grid Control and Optimization under High Level of Uncertainty**
- Brendan Kirby, P.E., Private Consultant: **Renewable Energy Integration: Variability & Uncertainty Impacts and Mitigation Options**
- Sean Meyn, Robert C. Pittman Eminent Scholar Chair – Dept. of ECE at the University of Florida, Director – Laboratory for Cognition & Control, Director – Florida Institute for Sustainable Energy (FISE): **From the Sunshine State to the Solar State**
- Ana Radovanovic, Google, Inc.: **The Grid of the Future**
- Hani Alarian, Director of Power System Technology Operations at CAISO: **Forecasting and Scheduling Renewable Generation for Operating a Reliable Grid**
- Nathan Mancha, Director of Demand Response for EDF Trading North America: **Asset Management Opportunities in the Evolving Energy Market**

The link to the event speakers and presentation slides can be found here.

FESC May 2015 Workshop

FESC workshop was held on May 20-21, 2015 at the Orlando Airport Marriott Lakeside in Orlando FL. Over 160 people attended. The workshop brought together energy experts in the State University System of Florida and industry to share their energy-related research findings and to promote future collaboration. The program featured internationally renowned speakers, as well as presentations and posters highlighting FESC's innovative work leading to alternative energy strategies, improved energy efficiencies and expanded economic development for Florida. Buck Martinez, Senior Director Office of Clean Energy, Florida Power & Light Company gave the opening speech on May 20 with a Welcome address followed by a host of panel sessions and discussions by prominent energy faculty and industry leaders from across the nation:

1. Amy L. Stein, Professor, UF Levin College of Law
2. Jeremy Susac, Berger Singerman
3. Meera Bagati , Sr. Economist, NextEra Energy Resources, LLC
4. Phillip Janca, Co-founder, Crowd Energy
5. Jim Noh, University of California, Berkeley
6. Ramon Gonzalez, Professor, Chemical & Biomolecular Engineering, Bioengineering, Director, Energy and Environment Initiative (EEI), Rice University
7. Miriam Makhyoun, Solar Energy Industry Expert

8. Jim Payne, Technology Project Officer, Office of Energy Efficiency and Renewable Energy, US DOE
9. Marija Ilic, Professor of Electrical & Computer Engineering and Engineering & Public Policy, Carnegie Mellon University
10. Jordan Kislear, Program Analyst at US Department of Energy

A free grant writing workshop led by Ben Rowland's company, national expert in proposal development and delivery, concluded the workshop on May 21, 2015.

The event agenda is given at: http://www.floridaenergy.ufl.edu/wp-content/uploads/finalagenda.pdf

The program book is given at: http://www.floridaenergy.ufl.edu/wp-content/uploads/finalprogrambook.pdf

All the presentations are posted at: http://www.floridaenergy.ufl.edu/public-outreach/fesc-may-2015-workshop/presentations/

Workshop photos are given at : http://www.floridaenergy.ufl.edu/public-outreach/fesc-may-2015-workshop/workshop-photos/

APPENDIX A – DESCRIPTION OF RESEARCH PROJECTS

Projects	Summary
THRUST 1: Overarching	
	Title: *Power Generation Expansion Portfolio Planning to Satisfy Florida's Growing Electricity Demands* **PI:** Tapas Das, **Co-PI**: Ralph Fehr - USF **Description**: The objectives of the proposed research include: 1) developing a comprehensive generation technology based portfolio optimization methodology, 2) developing carbon revenue redistribution strategies to achieve goals of emissions control policies (cap-and-trade), and 3) develop educational resources to enhance training of scientific workforce for the state of Florida. The research will directly address three major challenges: fulfillment of the growing power demand, meeting the emissions control targets, and supply of technology workforce. The potential economic impact of the proposed research on the State of Florida is expected to be very high, since an energy-secure environment is a basic necessity to support the current trend of explosive growth both in industry and human resources. **Budget:** $71,906 **External Collaborator:** Argonne National Lab
	Title: Joint Optimization of Urban Energy-Water Systems in Florida (Thrust 2: Efficiency)
	Title: Combined Cooling, Heat, Power, and Biofuel from Biomass and Solid Waste (Thrust 3: Biomass)
	Title: Design, Construction, and Operation of CSP Solar Thermal Power Plants in Florida (Thrust 4: Solar)
	Title: Development of High Throughput CIGS Manufacturing Process (Thrust 4: Solar)
	Title: Solar Photovoltaic Manufacturing Facility (Thrust 4: Solar)
	Title: Research to Improve Photovoltaic Cell Efficiency (Thrust 4: Solar)
	Title: An Integrated Sustainable Transportation System (Thrust 4: Solar)
	Title: PV Energy Conversion and System Integration (Thrust 4: Solar)
	Title: Integrated PV/Storage and PV/Storage/Lighting Systems (Thrust 4: Solar)
	Title: Reliable and Resilient Electrical Energy Transmission and Delivery Systems (Thrust 7: Storage & Delivery)
	Title: Secure Energy Systems – Vision and Architecture for Analysis and Design (Thrust 7: Storage & Delivery)
THRUST 2: Enhancing Energy Efficiency and Conservation	
	Title: Innovative Proton Conducting Membranes for Fuel Cell Applications **PI:** Ongi Englander, **Co-PIs:** Anant Paravastu, Subramanian Ramakrishnian - FSU **Description:** This project was initiated in January 2009 as an interdisciplinary effort among Englander (Mechanical Engineering), Paravastu (Chemical and Biomedical Engineering) and Ramakrishnan (Chemical and Biomedical Engineering). The work was divided into two main tasks: (1) the fabrication and characterization of silica and latex-supported membranes, and (2) the incorporation of protein nanomaterials inside the silica membranes. Three female students have participated and contributed to the project (see below). Two of the students (Holley and Kissoon) have received/will receive MS degrees in Materials Science. Two of the students (Kissoon and Witherspoon) belong to underrepresented groups. **Budget:** $30,000 ***This project has been completed***
	Title: Sustainably Integrated Advanced Building Subsystems (OGZEB) **PI:** A. "Yulu" Krothapalli, **Co-PI:** Justin Kramer - FSU **Description:** This project focused on the development of building subsystems that minimize the use of natural resources and carbon-based energy in Florida while also using materials that are renewable and sustainable. A key component of this project was the Off-Grid Zero Emissions Building, which allowed for the testing of these subsystems. This team forms the engineering team participating in the Team Florida's

	Solar Decathlon Competition. Lessons learned from the Off-Grid Zero Emission Building are incorporated into Team Florida's design. This project is complete. **Budget:** $503,168 ***This project has been completed***
	Title: Insight into Membrane Degradation Mechanisms Through Verification of Chemical and Mechanical Degradation Test Capabilities **PI:** Darlene Slattery, **Co-PIs**: Len Bonville, Marianne Rodgers - UCF/FSEC **Description:** The objectives of the program were to gain insight into fuel cell membrane degradation mechanisms including both chemical and mechanical degradations. In order to achieve this objective, the Membrane Electrode Assembly Durability Test System, MEADS, was verified, after which chemical degradation tests were conducted. By performing post mechanical testing and analyzing the data, the impact of accelerated degradation tests on the cell performance decay, chemical decomposition and mechanical weakening of the membranes were evaluated. This project is complete. **Budget:** $351,518 ***This project has been completed***
	Title: Energy Efficient Building Technologies and Zero Energy Homes **PI:** R. Vieira, **Co-PIs:** P. Fairey, J. Sonne - UCF/FSEC **Description:** The project consists of two elements: 1) the construction of two flexible research homes at FSEC to conduct research on advanced building energy efficiency technologies under controlled conditions; and 2) a staged, field retrofit study in a small number of unoccupied homes to measure and document the effectiveness of a series of retrofit measures that can be deployed using current technology. The project will also conduct an annual meeting where other FESC participants, other university members and utility, industry, the U.S. Department of Energy and other stake holders who will be briefed on plans and progress. Inputs from meeting participants will be sought. **Budget:** $1,224,000
	Title: Joint Optimization of Urban Energy-Water Systems in Florida **PI:** James P. Heaney - UF **Description:** Urban water infrastructure systems for providing water supply, collecting and treating wastewater, collecting and managing stormwater, and reusing wastewater and stormwater require major energy inputs. End users of the water require even more energy to heat this water for showers and baths, clothes washing, cooking and other uses. Increasingly, cities will rely on alternative water supplies such as desalination that require much more energy per gallon of water produced. Conservation is the ideal way to save energy and water by managing the demand for these precious commodities. Major strides have been made in reducing indoor water use from about 75 gallons per person per day to as low as 40 gallons per person per day. However, these gains are being offset by concurrent increases in outdoor water use for irrigation that range from 30 to 300 gallons per person per day depending on irrigation practices and the size of the landscape. From a water use perspective, perhaps the greatest challenge will be the expected growing competition for water if certain energy options are implemented in order to reduce our current dependence on foreign oil. Several recent national studies warn of this impending energy-water crisis. This project will build on our extensive experience in evaluating urban water conservation options to include the implications for energy use and to develop integrated energy-water management systems that are compatible. **Budget: $72,000** Back to Thrust 1: Overarching
	Title: Planning Grant: High Performance and Low Cost Fuel Cells for Future Vehicles **PI:** Jim Zheng, **Co-PIs:** Richard Liang, Chuck Zhang, Ben Wang - FSU **Description:** The objective of this project is to provide an innovative approach to revolution of current energy storage and conversion technology and greatly leverage FSU position in the strategic important area for sustainable energy. The project was performed by Drs. Jim Zheng and Richard Liang at the Department of Electrical and Computer Engineering and Department of Industrial Engineering, respectively. First to demonstrate preliminary results in high performance of energy storage and conversion materials and devices in order to seek outside funding consistent with the vision of IESES. The deliverables were conference proceedings and journal papers and proposal submissions for additional funding. This project is complete.

	Budget: $15,000 **Research Integration (collaboration):** NCSU and NHMFL on advantage batteries; Industrial Engineering on fuel cells; Maxwell Technologies, Inc. and Ionova Technologies, Inc. on supercapacitors; CAPS on microgrids; MARTECH on thermoelectric; Shanghai Institute of Technical Physics on photovoltaic; N. Dai, F.Y. Huang, S.L. Wang, X.N. Li, J.P. Zheng (co-PI), and D. Wei, "An International Collaboration Group on Solar Cell Technologies Development", Sponsor: Chinese Academy of Sciences, Budget: $877,193 (￥6,000,000 RMB), Project Dates: 4/09-4/14. ***This project has been completed***
	Title: NIRT: C-MEMS/CNEMS for Miniature Biofuel Cells **PI:** Marc Madou, Co-PIs : Chunlei Wang, Sylvia Daunert and Leonidas Bachas - FIU **Description:** In recent years, the quest for alternative sources that can autonomously power bioMEMS devices, especially those geared for in vivo applications, such as monitoring and drug delivery, has been the focus of research by scientists and engineers as new power sources will prove critical for the advancement of the field. Current batteries are still less than optimal and often present drawbacks related to safety, reliability and scalability. An ideal power source for implantable devices should take advantage of natural compounds present in the body of an individual and use them as fuel to produce power in a continuous and reproducible manner, as long as the patient's physiological functions remain steady. Biofuel cells, which are capable of converting biochemical energy into electrical energy, have been deemed as a potential solution to the drawbacks presented by conventional batteries, but the power density and operational lifetime requirements for implanted devices have not been met yet. To that end, we are integrating genetically engineered catalytic proteins and carbon-based 3 dimensional (3D) MEMS/NEMS structures to create new biofuel cells. The biofuel cell electrode surfaces, especially fractal electrode array, presents significantly increased surface area as compared to traditional architecture, increasing the biocatalyst loading capacity considerably for high power throughput. The genetically engineered enzymes inherently increase enzyme stability, consequently increasing biofeul cell lifetime. The scaled fractal electrode surface plays a role in wiring the enzymes to the biofuel cell anode, which increases the electron transfer efficiency from the enzyme to the electrode for an increase in the overall performance of the biofuel cells. Furthermore, C-MEMS/C-NEMS architectures will enable the reproducible fabrication of low cost carbon-based electrode structures. **Budget:** $171,432 (PI portion) (total amount: $1,000,000) - *Not Funded by FESC.*
	Title: Fabrication of Nano Fractal Electrodes for On-Chip Supercapacitors **PI:** Chunlei Wang - FIU **Description:** Nature has always strived for the highest efficiency in all organisms. Just as nature has benefited from fractal structures in almost all of its organisms, biomimetic fractal designs in electrochemical devices such as power conversion & storage devices and sensors can also lead to benefits in scaling. Our proposed concept is geared to take advantage of the scaling relationship between interface area and overall volume. Fractal electrode design is believed as a promising solution to optimize surface area while minimizing the internal resistance. We will fabricate and characterize carbon-based microelectrodes pyrolyzed from photolithographically patterned photoresist, which exhibits nano fractal geometry by design. In contrast with the current research trend of, first fabricating carbon nanostructures (CNTs, CNFs, etc), and then lithographically defining an electrode at the convenient location on the substrate, our novel methods will integrate the fabrication of the micro and the nano- structures using simple process thus bridging the gap that separates these two scales. Since the fabrication methods are all based on IC manufacturing methods, it will be easy to integrate into microchips. **Budget:** $150,000 - *Not Funded by FESC.*
	Title: Energy Efficient Technologies and The Zero Energy Home Learning Center **PI:** Stanley Russell, **Co-PIs:** Yogi Goswami **Graduate Assistant**: Mario Rodriguez - USF **Description:** The project is to create and evaluate an affordable residential scale Zero Energy building that will function as an exhibition of energy efficiency and Zero Energy Home [ZEH] technology on or near the University of South Florida campus. The project will feature the most cost-effective combination of renewable solar energy with high levels of building energy efficiency. The building will incorporate a

	carefully chosen package of the latest energy-.efficiency technologies and renewable energy systems to achieve the most successful and reliable results. The building will utilize Photovoltaic solar electricity and solar domestic hot water heating systems using the grid as an energy storage system, producing more energy than needed during the day and relying on the grid at night. Plug-in hybrid automobile technology offers a promising means of providing distributed energy storage for such homes but has not been sufficiently tested. Using a systems approach to couple zero energy home technology with PHEVs we will explore opportunities to develop marketable products that meet Florida's energy and environmental goals. **Budget:** $344,600 **External Collaborators:** FSU College of Engineering- Justin Kramer, Brenton Greska; UF- Department of Interior Design- Maruja Torres, Nam-Kyu Park; UF Rinker School of Building Construction- Robert Ries; UCF Florida Solar Energy Center- Stephanie Thomas Ries; Beck Construction; Hees and Associates Structural Engineers.
	Title: Unifying Home Asset & Operations Ratings: Adaptive Management via Open Data & Participation **PI**: Mark Hostetler, **Co-PI:** Hal S. Knowles, III - UF **Description**: Recent environmental, social, and economic challenges are fostering a wave of interest in maximizing energy efficiency and conservation (EE+C) in existing U.S. homes. Long standing programs, ratings, and metrics are being reapplied into new stimulus initiatives such as the *Recovery through Retrofit*[1] program. Simultaneously, electric and gas utilities are expanding their demand side management (DSM) programs from weatherization and conventional technology replacement incentives to include conservation behavior campaigns with "recommendation algorithms" designed to assist in homeowner energy retrofit decision making. Furthermore, loan programs are emerging to address the financial barriers that commonly limit initiation of the necessary retrofits. Collectively, these approaches most often project future home energy performance based on engineering models of the physical characteristics of homes (i.e., "asset ratings"). Yet to date, the marketplace is inadequately integrating historical household energy consumption patterns (i.e., "operational ratings") into the decision tree to optimize retrofit program efficacy and consumer benefits. Moving toward the unification of asset and operational ratings is crucial for successful program management, proper monitoring/measurement/verification (MMV), loan risk assessment, and for the persistence of reduced home energy use over time. However, unification will not be easy. This research project combines qualitative and quantitative research methods in social science and building science using Florida case studies to evaluate the opportunities and constraints of asset and operational rating unification and the steps necessary to get there. Relationships between our project and the collaborative, transparent, and participatory nature of "open government" initiatives are also being explored. **Budget**: $24,000 **External Collaborators:** Nick Taylor (Ph.D. Student, UF School of Natural Resources & Environment), Jennison Kipp (Assistant In, UF Program for Resource Efficient Communities)
	Title: Meteorological Factors Affecting Solar Energy Efficiency **PI:** Paul Ruscher **Co-PIs:** (formerly Yaw Owusu, Hans Chapman - FSU **Description:** There are numerous meteorological factors that limit the efficiency of solar energy systems in the tropics. Depletion of available solar energy at the surface by increased water vapor, cloudiness, temperature of the solar panel system, pollution, are sometimes overlooked, because engineering specifications for design are often based upon midlatitude continental air masses. The typical tropical atmospheric reduction factors were reviewed using a state of- the-art solar energy model for this project. In addition, meteorological variability can be quite extreme in the tropics and many engineering studies on feasibility of renewable energy sources in general are often based upon "typical" year criteria, rather than longer term climatologies. It is suggested that climatological data be utilized to more accurately portray the variability of output to be expected at a typical installation. Many of these variables are already widely

	available from a combination of surface and upper air meteorological stations, as well as remote sensing data from satellites. We demonstrated the sources for these data as well as strategies for teaching about solar energy efficiency using routine observations from school-based weather stations. This project is complete. **Budget:** $15,000 ***This project has been completed***
THRUST 3: Developing Florida's Biomass Resources	
Algae	
	Title: Establishment of the Center for Marine Bioenergy Research: Systems Approach to BioEnergy Research (SABER) **PI:** J. Kostka (he has left FSU), **Co-PIs**: William Cooper, Ivonne Audirac, Amy Chan-Hilton,Ellen Granger – FSU **Description:** IESES' Systems Approach to Bio-Energy Research (SABER) is particularly focused on coupling algal cultivation to wastewater nutrient remediation. SABER has partnered with the City of Tallahassee's T. P. Smith Waste Water Treatment Plant in order to study the growth of local fresh water algae in waste water for use as biofuel. The two main objectives of this project are to: 1) perform both laboratory and field experiments to test for species-specific growth potentials, as well as for the effects of different environmental parameters, including light, carbon dioxide, and nutrient availability on microalgal growth rates and lipid production, and 2) determine the extent to which microbes (i.e. bacteria), which are exceptionally abundant in waste water, act as either competitors (for nutrients, carbon) or symbiotically with algae. To do this we are examining the bacterial community present in the waste water and detecting community shifts that occur during algae cultivation. We are also examining the nutrient uptake dynamics between bacteria and algae by monitoring the usage and production of nitrogen, phosphorous, and carbon-containing compounds. Finally, a number of advanced analytical chemistry techniques are being used to characterize wastewater before and after algae cultivation. With a better understanding of the microbial and biogeochemical processes occurring in waste water during algae cultivation, engineering approaches may be proposed in order to further optimize algal growth in waste water. **Budget:** $494,135 **External Collaborators:** City of Tallahassee ***This project has been completed***
	Title: Constructual Optimization of Solar Photo-Bioreactors for Algae Growth **PI:** Juan Ordonez - FSU **Description**: This was a planning grant (15K, only). The work was targeted towards placing us in a more competitive position in future submissions in the area of bio-fuels. By the end of this one-year effort we now have a complete design of a small-scale photo-bioreactor for algae growth, obtained additional funds that will allow us to build a large-scale photo-bioreactor and conduct the necessary research for its optimal design and operation. This project is complete. **Budget:** $15,000 **External Collaborators:** Federal University of Parana, Brazil ***This project has been completed***
	Title: Optimization of Algae Species for Biofuels Production Using Genetic Altration **PI:** Ed Phlips- UF **Description:** This study will begin in June, 2011, and will focus on genetically altering selected species of algae to optimize their performance in biomass production systems aimed at biofuels. Two approaches to genetic alteration will be explored: mutagenesis and transformation. **Budget:** $15,000
High Energy Crops	
	Title: Energy Intensive Crop Development **PI:** Gary Peter , Matias Kirst, Don Rockwood - UF **Description:** To build a commercially viable, industrial scale system to produce transportation fuels and electricity from biomass requires both efficient conversion technologies and environmentally sustainable, cost effective supplies of biomass. In the US, Florida ranks first in its annual growth of plant biomass,

	because of its large cultivable land area and its subtropical climate, even though substantial land areas that can be planted are not currently in agricultural or forest production. The development of high yielding production systems for dedicated energy crops is considered essential for a sustainable, biomass to energy industry to be established, because the long-term availability of sufficient amounts of reasonably priced biomass is one of the most important factors in the site selection for new biofuel and bioenergy facilities. Dedicated energy crops are ones that 1) have high yields with minimum energy inputs in terms of agronomic practices, water and nutrient applications, 2) can be harvested, transported and processed efficiently into fuel or power, and 3) can be grown sustainably for generations without adverse environmental affects, or significantly impacting the food supply. We will evaluate likely energy crop species, *Eucalyptus* and southern pine to provide important yield and best management practices for growing these species for bioenergy conversion. We will also provide important chemical composition information that will impact the conversion efficiency of this biomass to ethanol, and identify and characterize important genes that regulate wood chemical composition **Budget:** $432,000
	Title: Water-Use Efficiency and Feedstock Composition of Candidate Bioenergy Grasses in Florida **PI:** Lynn E. Sollenberger, **Co-PI's:** John Erickson, Joao Vendramini, Robert Gilbert - UF **Description:** Florida ranks first in the USA in annual growth of plant biomass because of a large cultivatable land area, high rainfall, and long growing season. In order to capitalize on these advantages, the agricultural production sector and biomass conversion industries require information regarding which crops are adapted to particular Florida regions and local environments, how much biomass can be produced during what times of the year, which crops produce the most biomass per unit of water used, and which crops have the desired yield and composition for particular bioenergy applications. Research conducted to date has quantified the seasonal biomass supply provided by the most likely crops for use in Florida, identified crops and management practices that result in most efficient water use, and described the chemical composition of these plants to allow estimates of potential energy production per unit of biomass. Florida growers and industry representatives have gained access to this information through on-line resources, presentations by several of the project investigators at the Florida Farm to Fuel Conference, and by attending the Bioenergy Crop Field Day at the University of Florida Plant Science Research and Education Unit. Seven graduate students are being trained through this project and undergraduate students are gaining invaluable research experience via internships mentored by project investigators. Faculty involved in the FESC project have formed collaborations regarding agronomic and breeding projects with Speedling, Inc., SERF, and BP. Both SERF and BP plan to construct ethanol facilities in Florida that would create an estimated 400 temporary construction jobs and 140 permanent jobs each. **Budget:** $191,981 **External Collaborators: :** Speedling, Inc., Nutri-Turf, Inc., British Petroleum (BP), and Southeast Renewable Fuels (SERF)
Biochemical Conversion	
	Title: Development of Biofuel Production Processes From Synthetic and Biomass Wastes **PI:** Pratap Pullammanappallil - UF **Description:** With the ever-increasing price of petroleum and its finite supply, it is of high priority to develop domestic sources of transportation fuel, as well as other chemicals. Ethanol is an attractive alternate fuel that is being produced from corn starch. It is necessary to target other feedstocks for biofuel production and develop processes that have a minimal environmental impact. There is considerable ongoing research on developing processes and catalysts for conversion of biomass to biofuels like ethanol (called cellulosic ethanol process). But this project addresses other feedstocks with the following objectives: 1) development of biocatalysts for the conversion of waste biodegradable poly lactic acid based plastics to ethanol and 2) development of processes that processes for the production of additional fuels like biogas, bio-oil and biochar from the waste and byproducts of a cellulosic ethanol plant for the cleanup and reuse of these waste streams **Budget:** $192,000 **External Collaborators:** University of Central Florida
	Title: Engineering Biocatalysts for Hemicelluloses Hydrolysis and Fermentation

	PI: James F. Preston - UF **Description:** Our goal is to develop biocatalysts for the cost-effective production of fuel alcohols and chemical feedstocks from underutilized sources of renewable biomass and evolving energy crops. To reach this goal protocols for efficient saccharification of hemicellulose fractions from these resources will be developed. Objectives are to: 1. Develop improved enzyme-mediated saccharification protocols of hemicelluloses with existing bacterial biocatalysts for production of biofuels and chemical feedstocks. 2. Develop Gram positive biocatalysts for direct conversion of hemicelluloses to biobased products. 3. Develop systems with bacterial biocatalysts for efficient bioconversion of the hemicellulose fractions of perennial energy crops (poplar, eucalyptus, switchgrass, energy cane) to targeted products. **Budget:** $192,000 **External Collaborators**: Collaborations are in various units within the University of Florida: L.O. Ingram and K.T. Shanmugam, Microbiology and Cell Science; F. Altpeter, Agronomy; G. Peter, Forest Resources and Conservation.
	Title: Thermophilic Biocatalysts for the Conversion of Cellulosic Substrates to Fuels and Chemicals **PI:** K.T. Shanmugam - UF **Description:** Biomass is an attractive source of sugars for a state like Florida that produces very limited amount of corn for fermentation to produce ethanol as transportation fuel or other products such as lactic acid that can be converted to bioplastics. Florida currently generates about 8.7 million tons of dry cellulosic biomass per year (US-DOE) that can be converted to about 0.7 billion gallons of ethanol. With specific energy crops and short rotation trees cultivated for energy production using the abundant sunshine and water resources, the ethanol produced from biomass can be significantly increased to meet the demand for transportation fuel in the State of Florida. Before biomass-based fuels and chemicals become an economic reality, several key steps in the depolymerization of biomass to constituent sugars need to be addressed. One is depolymerization of cellulose to glucose by fungal cellulases before fermentation to ethanol by microbes. The current estimated cost of fungal cellulases is $0.32 per gallon ethanol produced and this cost is targeted for reduction to $0.10 or less by year 2012 (DOE). We have demonstrated that by increasing the temperature of Simultaneous Saccharification and Fermentation (SSF) of cellulose from 30-35 ºC to 50-55 ºC, the amount (and associated cost) of cellulases can be reduced by the required 3-fold with the current commercial enzyme preparations. A microbial biocatalyst that produces ethanol or other chemicals as the main fermentation product and can also function at this higher temperature and pH 5.0 in conjunction with the fungal cellulases in the SSF process is a critical component of this process. We have identified a thermophilic facultative anaerobe, *Bacillus coagulans*, with versatile metabolic capability as the microbial platform for the SSF of biomass to products and engineering this L(+)-lactic acid producing bacterium to produce ethanol. *The primary objective of this proposed study is to construct a B. coagulans derivative that produces ethanol as primary product of fermentation and to enhance the ethanol productivity of the engineered derivative.* **Budget:** $192,000 ***This project has been completed***
Bio gasification	
	Title: Combined Cooling, Heat, Power, and Biofuel from Biomass and Solid Waste **PI:** William Lear, **Co-PI:** J.N. Chung - UF **Description:** The goal of this project is to provide the underlying research and demonstration of a novel technology which would enable the economic utilization of dispersed biomass and solid waste resources to produce electric power, cooling, heat, and transportation fuels. This integrated gasification and power generation system combines University of Florida advances in high-temperature gasification, hydrogen generation and separation, and advanced gas turbine systems. Their integration is expected to result in significant improvements in the cost, emissions, feedstock flexibility, and water requirements, all in a relatively compact, modular plant system. This in turn will enable much greater utilization of renewable energy supplies, helping the development of a sustainable energy supply infrastructure. **Budget:** $576,000

	External Collaborators: Siemens Power Generation, Florida Turbine Technologies, Energy Concepts Co., Nu-Power Technologies LLC, PlanetGreenSolutions Inc., LPP Combustion, LLC. Back to Thrust 1: Overarching
Thermo-Chemical Conversion	
	Title: Production of Liquid Fuels Biomass via Thermo-Chemical Conversion Processes **PI:** Babu Joseph, **Co-PIs:** Yogi Goswami, Venkat Bhethanabotla, John Wolan, Vinay Gupta - USF **Description:** The objective of this project is to develop technology for the economical thermo-chemical conversion of lingocellulosic biomass (non-food grade biomass such as agricultural waste, bagasse from sugar mills, citrus peels, switch grass, municipal green waste, etc.) to clean burning liquid fuels. Five of the major advantages of this process over a biochemical route to production of ethanol are: (i) it does not utilize food-grade feed stocks and therefore complements and does not compete with the agricultural food production in the state, (ii) the fuel produced is similar to those derived from petroleum unlike ethanol derived fuels which have at least a 25% lower energy content, (iii) the conversion is accomplished in using fast chemical reactions unlike the slow biological reactions for fermenting alcohol, (iv) the process does not require large amounts of water and associated energy costs of separating the water from the fuel as in bioethanol processes, (v) it can utilize a wide variety of biomass sources unlike the biochemical route which cannot work with high lignin containing biomass. **Budget:** $554,447 **External Collaborators:** Prado & Associates
	Title: Feasibility, Sustainability and Economic Analysis of Solar Assisted Biomass Conversion **PI:** Babu Joseph, **Co-PI:** Q. Zhang - USF Description: The main deterrent for commercialization of biomass conversion processes is the cost of conversion; particularly the need to sacrifice as much as 30% of the energy content in the biomass for the thermo chemical conversion step. We want to research and develop the concept to use solar thermal energy from concentrating units to provide energy for the biomass gasification step. We also propose to evaluate the sustainability of such a process. Overall Objective: The overall objective is to conduct a theoretical analysis of solar assisted thermo chemical conversion of biomass from the point of view of energy efficiency, economic feasibility, environmental impact, and long term sustainability of renewable energy production. **Budget:** $45,238
	Title: Integrated Florida Bio-Energy Industry **PI:** Ali T-Raissi **Co-PIs:** N.Z. Muradov, D.L. Block - UCF/FSEC **Description:** The aim of this project continues to be production of liquid hydrocarbon fuels derived from lignocellulosic and aquatic biomass employing a two-step thermocatalytic process. In the first step, pre-treated biomass is gasified with oxygen (or air) and steam yielding synthesis gas (syngas) containing hydrogen and carbon monoxide. In the second step, syngas generated by the gasifier enters a Fischer Tropsch (FT) synthesis unit where it reacts to form a range of liquid hydrocarbon fuels – including diesel. **Budget:** $648,000
	Title: Biofuels Through Thermochemical Processes: Approach to Produce Bio-Jet Fuel **PI**: Anjaneyulu Krothapalli - FSU **Description:** The objective of this project was to develop technologies to produce biojet and biodiesel fuels from sustainable sources such as bio-oils and hydrogen produced from biomass generated synthetic gas. Novel processing concepts, reactor design and catalyst systems are employed in this integrated approach to convert any cellulosic biomass and any nonedible bio-oils into bio-jet fuel (Figure 1). Feedstock flexibility offers significant cost and logistic advantages to this approach. Unlike other processes which use only the oil derived from a plant, the entire plant can be used as feedstock source and the proposed approach can also convert the more challenging lignocellulosic component. This project is complete. **Budget:** $229,572 ***This project has been completed***
Biomass Suspension Rheology	
	Title: Simulation and Measurement of Biomass Suspension Rheology

	PI: Jennifer Sinclair Curtis – UF Project Period: 8/2014-7/2016 **Description:** Biomass is a promising source of renewable energy. Although this form of energy production holds much potential to reduce energy dependence on petroleum-based fuel consumption, one key challenge in the large-scale commercialization of these systems is the physical handling of biomass suspensions. These suspensions span a wide spectrum of solids concentrations and particle size during the various biomass processing steps. A combined program of simulation and experimentation is utilized to investigate the dynamics and rheology of fibrous suspensions of biomass. In order to reliably design and optimally operate biomass processes, the rheological behavior of these complex fluids over a range of solids concentrations and particle size must be understood. On the simulation side, the discrete element method, capable of calculating stresses and effective viscosity of biomass over a wide span of moisture content (using a liquid bridging model) and particle sizes, is developed. The rheology of well-characterized fibrous suspensions (wheat straw and corn stover) will be fully evaluated and compared with the simulation results. The shear rheology will be measured using a vaned geometry. Successful completion of the proposed work will provide insights into the rheological behavior of fiber-filled suspensions that will aid the design and optimal operation of processes in renewable energy. **Budget:** $100,000
THRUST 4: Harnessing Florida's Solar Resources	
Solar Testing Facility	
	Title: Solar Systems Testing Facility **PI:** James Roland, David Block - UCF/FSEC **Description:** Over the past four years, the Florida Solar Energy Center (FSEC) has received a significan increase in demand for solar and PV systems testing and certification. This occurrence has resulted in requirin the Center to correspondingly amplify its capabilities to respond to the increased demand. Thus, the objectiv of this task was to construct a solar and PV systems testing facility by adding walls, windows, doors and A/C to an existing Florida Solar Energy Center roof only facility. The enclosing of this existing space was done fo the purpose of increasing laboratory space and to allow for laboratory testing of solar water heating system and PV modules and inverters. The action was taken following a study which determined this project was th most cost effective means of adding valuable indoor laboratory space. **Budget:** $600,609 ***This project has been completed***
Solar Thermal	
	Title: Concentrating Solar Power Program **PI:** Charles Cromer, R. Reedy - UCF/FSEC **Description:** The objective of this effort is to produce a detailed Florida map of the solar direct beam and global resource available for use in Florida whereby a potential user of solar energy can enter their location latitude and longitude and receive a table of solar energy monthly averages for that specific site as derived from the past eleven years of data. The concept is to use NOAA satellite photos and utilize the brightness of the cloud cover as a clearness factor predictor of the solar energy that gets through to the ground below. **Budget:** $52,000 **External Collaborators:** FPL ***This project has been completed***
	Title: Development of Novel Water Splitting Catalysts for the Production of Renewable Hydrogen **PI:** Helena Hagelin-Weaver - UF **Description:** This project focuses on the development of iron-based catalysts for the thermochemical splitting of water into hydrogen and oxygen. The thermochemical process of splitting water is particularly well-suited for the utilization of solar energy to provide the heat for the reaction and is a way to produce a renewable hydrogen fuel. As hydrogen is difficult to transport and store, producing hydrogen on site for power plants using proton exchange membrane (PEM) fuel cells or internal combustion engines to generate electricity or for the production of chemicals, such as liquid hydrocarbon fuels, is a very attractive approach. The project uses a two-step process in which water is passed over a reduced iron oxide to

	generate hydrogen while the oxygen is taken up by the oxygen-deficient iron oxide (Step 1: FeOx-1 + H2O □FeOx + H2). In the second step the resulting iron oxide is heated to desorb oxygen and regenerate the oxygen-deficient iron oxide to close the catalytic cycle (Step 2: FeOx □FeOx-1 + ½O2). The main objectives of the project are to develop mixed metal oxide catalysts that 1) will release oxygen at temperatures lower than 1500°C (Step 2), while still maintaining water-splitting activity (Step 1) and 2) are stable up to the temperature necessary for the oxygen desorption step. **Budget:** $ 100,000
	Title: Enhanced and Expanded Solar Thermal Test Capabilities **PI:** J. Del Mar**,** R. Reedy - UCF/FSEC (PI use to be J. Walters) **Description:** The Florida Solar Energy Center (FSEC) serves the State of Florida by providing independent, third-party testing and certification of solar equipment for the main purposes of providing product value in the marketplace, especially for products that are not widely "proven" with consumers such as solar water heating systems and solar electrical (photovoltaic) systems. Even more important, third-party certification provides protection to reputable manufacturers, ensuring that lower quality products, often from foreign markets, do not compete head-to-head with Florida and U.S. products unless they meet the same standards. **Budget:** $809,295 **External Collaborators:** Solar thermal manufacturers
	Title: Solar Fuels for Thermochemical Cycles at Low Pressures **PI:** Jörg Petrasch - UF **Description:** The project focuses on the production of solar fuels from solar thermochemical cycles employing metal/metal oxide redox pairs. These thermochemical cycles consist of a high temperature endothermic solar driven reduction step and a low temperature, slightly exothermic water or CO2 splitting step. The high temperature step typically proceeds at temperatures above 2000 K. Hence, it poses a range of material and design challenges. According to Le Chatelier's principle, the temperature for the solar dissociation reaction decreases as the pressure inside the reactor is reduced. The central hypothesis of the project is that operating the high temperature step of metal/metal oxide solar thermochemical cycles at reduced pressures will lead to significantly relaxed temperature requirements, while the work necessary to produce the pressure difference will not significantly reduce the overall efficiency of the process. The main goal of the project is to demonstrate the feasibility of carrying out high temperature thermal reduction of metal oxides in rarefied conditions using high intensity solar radiation from UF's solar simulator. **Budget:** $ 100,000 **External Collaborators:** Wojciech Lipinski, University of Minnesota
	Title: Solar Thermal Power for Bulk Power and Distributed Generation **PI:** David Hahn, **Co-PIs:** James Klausner, Renwei Mei, Helena Weaver - UF **Description:** While there are many different approaches to hydrogen generation, the most attractive means is to split water molecules using solar energy. The current approach is to develop highly reactive metal oxide materials to produce intermediary reactions that result in the splitting of water to produce hydrogen at moderate temperatures (<1000 K). It is envisioned that the metal oxide reactors will ultimately be mounted within a solar concentrating reactor, and irradiated via heliostats. This Task is structured toward the overall goals of solar-driven, thermochemical hydrogen production, with associated efforts toward the enabling surface science, catalysis, particle science, material synthesis, nano-structures, multiscale-multiphase physics modeling, and process simulation that will enable the realization of solar hydrogen-based fuels to power the transportation economy. Successful efforts as targeted in this project are a critical step toward increased renewable-resource based fuels and energy, reduction of GHG emissions, and establishment of a new power industry in Florida. **Budget:** $446,400
	Title: Design, Construction and Operation of CSP Solar Thermal Power Plants in Florida **PI :** Yogi Goswami, **Co-PIs:** Lee Stefanakos, Muhammad Rahman, Sunol Aydin, Robert Reddy - USF Florida utilities are mandated to achieve 20% renewable energy contribution to their generation mix by 2020. While technologically feasible with solar energy, the capital costs are high – presently, capital costs range from $6,000-$7,000/kW for PV and $3,500-$4,000/kW for concentrating solar thermal power. This project

	targets the development of solar thermal power technology for bulk power and distributed generation, which will diversify energy resources in Florida and reduce greenhouse emissions by utilizing renewable sources. Also, there will be economic impacts with the establishment of new power industry in Florida, which will help the electrical utilities of the state to meet the renewable portfolio standards. The project has three main tasks; the first one is to develop design methodologies and standards for the proven solar thermal power technologies in combination with bio or fossil fuels based on Florida conditions and resources. Secondly, the project aims to set up demonstration and test facilities for these technologies for optimization for Florida conditions, and the final task is to develop and commercialize innovative technologies based on new thermodynamic cycles. **Budget:** $882,000 **External Collaborators:** Sopogy Inc. and Gulf Coast Green Energy. Back to Thrust 1: Overarching
	Title: Multi-Generation Capable Solar Thermal Technologies **PI:** A. Krothapalli, **Co-PI:** Brenton Greska - FSU **Description:** The objective of the research was to develop and demonstrate small-scale solar thermal technologies that can be used separately, in conjunction with one another, or with existing waste heat producers, thus improving the overall system efficiency. This project is complete. **Budget:** $544,226 ***This project has been completed***
Clean Drinking Water	
	Title: Low Cost Solar Driven Desalination **PI:** James Klausner - UF **Student:** Fadi Alnaimat/ Ph.D **Description**: This work concerns the development of a cost effective, low power consumption, and low maintenance desalination process that is powered by solar energy. The solar diffusion driven desalination (DDD) process is most suitable for decentralized applications. While theoretical models have been developed to analyze the evaporation and condensation processes of the solar DDD under transient operating conditions (Alnaimat et al., 2011), experimental investigations have been conducted to validate the theoretical models. In this reporting period, the overall distillation performance of the solar DDD has been investigated under different design and operating conditions. The best operating modes have been proposed to improve the water production and reduce the specific energy consumption. **Budget:** $252,000 **University:** UF
	Title: Clean Drinking Water using Advanced Solar Energy Technologies **PI:** Lee Stefanakos **Co-PI's:** Yogi Goswami, Matthias Batzill, Maya Trotz, Sesha Srinivasan - USF **Description:** Availability of fresh water is one of the biggest problems facing the world and Florida is one of the most vulnerable to fresh water shortages. Moreover, Florida ground water is contaminated in many locations from leaky underground tanks, agricultural pesticides, and other chemicals. Although it is possible to desalinate abundant seawater, conventional systems are too energy intensive. Solar energy can provide the needed energy, and innovative new solar vacuum (USF) and humidification/dehumidification (UF) desalination systems can provide adequate fresh water for the state's needs. Systems are being developed for both bulk water desalination and small community needs/disaster response. We will also develop photocatalytic disinfection to remove contaminants and integrate these technologies with solar PV for complete water supply systems. Photocatalysis is a promising water treatment technology capable of utilizing solar light. However, the construction of an effective photocatalytic disinfection system for water purification is currently limited by the lack of reliable models to aid in the design and testing of these systems. Simplified models have been proposed, but most are inadequate because they rely on traditional disinfection theories which are not applicable to photocatalysis. Therefore, the major goal of this research is to develop a model for photocatalytic disinfection based on fundamental processes which may then be used to design water treatment systems in the state of Florida.

	Budget: $326,756 **External Collaborators:** NA
Low Cost PV Manufacturing	
	Title: Enhanced and Expanded PV Systems Testing Capabilities at FSEC **PI:** S. Barkaszi, **Co-PI:** R. Reedy - UCF/FSEC **Description:** An important FSEC function is consumer protection from poorly designed and manufactured PV modules and systems. FSEC's test capabilities were established over 10 years ago and were adequate at the time to test PV modules for certification. However, PV costs have fallen and competing electric utility rates have risen. In the last two years, these curves have crossed under some economic scenarios and incentive programs, and the demand for PV module testing and system certification has jumped. Thus, this task will provide for enhanced and expanded PV testing and certification capabilities. The task will also be done in close coordination with FSEC's work with the U.S. Department of Energy's PV program. **Budget:** $196,018
	Title: Development of High Throughput CIGS Manufacturing Process **PI:** Neelkanth Dhere - UCF/FSEC **Description:** A reduction in the cost of CIGS and other thin film PV modules is required for broad PV applications. The objective is to develop a high-rate deposition process for synthesis of CIGS absorbers and other layers by employing in-line and batch deposition techniques. The goal is finally to attract a PV manufacturing company to Florida by developing a high-rate manufacturing process for $CuIn_xGa_{1-x}Se_2$ (CIGS) solar cells. **Budget:** $141,620 Back to Thrust 1: Overarching
	Title: Florida Opportunities for PV Manufacturing and Applications **PIs:** D. Block, J Fenton, P. Fairey, W. Schoenfelds, R. Reedy - UCF/FSEC **Description:** The overall goal of this project is to assist in the development of a photovoltaic (PV) manufacturing industry in Florida. The project objective is to conduct a review of the state, national and international PV manufacturing data for the purposes of establishing industry practices and an industry data base. The data base will then be available to assist Florida in establishing PV manufacturing firm(s). **Budget:** $81,120
	Title: Development of Low Cost CIGS Thin Film Hot Carrier Solar Cells **PIs:** Gijs Bosman, **Co-PI:** Tim Anderson - UF **Description:** Our study is focused on hot carrier solar cells for cell conversion efficiency improvement in a low cost, high throughput CIGS system. The rapid thermalization loss of hot photoexited carriers interacting with the lattice can potentially be reduced through phonon engineering in the absorber layer; the subsequent extraction of the hot carriers may be realized through device engineering of energy selective contacts. **Budget:** $450,000
	Title: Solar Photovoltaic Manufacturing Facility to Enable a Significant Manufacturing Enterprise within the State and Provide Clean Renewable Energy **PI:** Don Morel – USF, **Co-PIs:** Chris Ferekides, Lee Stefanakos - USF **Description:** The primary goal of this project is to enable the establishment and success of local solar photovoltaic manufacturing companies to produce clean energy products for use within the state and beyond and to generate jobs and the skilled workforce needed for them. Thin film technologies have shown record efficiencies of 20%, and present tremendous opportunities for new Florida start-up companies. USF, UCF, and UF are collaborating to develop a pilot line facility for thin film solar technologies, which will serve as a test bed for making ongoing improvements in productivity and performance of solar modules, develop advanced manufacturing protocols, and help train a skilled workforce to ensure the success of new companies. **Budget:** $1.6M **External Collaborators:** Mustang Solar, a Division of Mustang Vacuum Systems Back to Thrust 1: Overarching
Advanced PV Device Program	

	Title: Research to Improve Photovoltaic (PV) Cell Efficiency by Hybrid Combination of PV and Thermoelectric Cell Elements. **PIs:** Nicoleta Sorloaica-Hickman**,** Robert Reedy - UCF/FSEC **Description:** Photovoltaic/thermoelectric (PV/TE) cell integration is a promising technology to improved performance and increase the cell life of PV cells. The TE element can be used to cool and heat the PV element, which increases the PV efficiency for applications in real-world conditions. Conversely, the TE materials can be optimized to convert heat dissipated by the PV element into useful electric energy, particularly in locations where the PV cell experiences large temperature gradients, i.e. use the thermoelectric module for cooling, heating and energy generation depending on the ambient weather conditions. Thus, the goal of this research effort is to research and develop nanoscale design of efficient thermoelectric material through a fundamental understanding of the materials properties and to design and build a photovoltaic thermoelectric (PV/TE) hybrid system. **Budget:** $167,820 Back to Thrust 1: Overarching
	Title: PV Devices Research and Development Laboratory **PI:** Robert Reedy **Co-PI's:** Nicoleta Sorloaica-Hickman, Neelkanth Dhere - UCF/FSEC **Description:** The primary challenge facing the PV industry is to dramatically reduce the cost/watt of delivered solar electricity by approximately a factor of 2 to 3, to increase the manufacturing volume by a factor of 10 and to improve the cell efficiencies by a factor of 2 to 3. This task will conduct R&D on basic science of PV cells and develop a world class PV cell laboratory for future cell research. The R&D will focus on developing new and improved PV cells such as organic PV, nano-architectures, multiple excitation generation, plasmonics, and tandem/multi-junction cells. **Budget:** $450,250
	Title: Beyond Photovoltaics: Nanoscale Rectenna for Conversion of Solar and Thermal Energy to Electricity **PI:** Shekhar Bhansali, **Co-PIs:** Elias Stefanakos, Yogi Goswami, Subramanian Krishnan - USF **Description:** The main objective of the proposal is to commercialize and scale up a new technology, rectenna to convert waste heat energy to electricity. Although the prediction of highly efficient (~85%) solar rectennas was published almost 30 years ago, serious technological challenges have prevented such devices from becoming a reality. Since the ultimate goal of a direct optical frequency rectenna photovoltaic power converter is still likely a decade away, we plan to convert optical solar radiation to thermal radiation (~30 THz regime) using an innovative blackbody source. Leveraging the research efforts of the world-class team members, we plan to further develop the rectenna technology that is within reach of efficient radiation conversion at 30 THz. A fully integrated, blackbody converter and 30 THz rectenna system will be capable of converting at least 50% of solar and thermal energy into usable electrical power, clearly demonstrating a truly transformational new technology in the renewable energy technology sector. **Budget:** $598,500 **External Collaborators:** Bhabha Atomic Research Center, India
PV Integration	
	Title: PV Energy Conversion and System Integration **PI:** I. Bataraseh, **Co-PI's:** J. Shen, Z. Qu, X. Wu, W. Mikhael, L. Chow – UCF (PI use to be N. Kutkut) Description: The objective of this project is to develop a system-driven Plug'N'Gen solar power system demonstrating architecture of decentralized, low-cost, mass-produced, PV panel-mounted micro-inverters. This system will be able to compete with today's centralized multi-kW PV inverters that require cost prohibitive professional installation. The project tasks are: 1) novel inverter topology and control concepts; 2) advanced digital control algorithms; 3) SmartTie interface with the utility grid; and 4) low cost and ultra-compact PV inverter in package. **Budget: $1,267,000** Back to Thrust 1: Overarching
	Title: Non-Contact Energy Delivery for PV System and Wireless Charging Applications **PI:** Jenshan Lin - UF

	Description: Innovative non-contact energy delivery method will be used in photovoltaic energy generation system to accelerate the system deployment. Instead of delivering electric power using cables penetrating through building structures, magnetic field coupling allows power to be transferred wirelessly through building walls and roofs. In the meantime, the DC electric energy from photovoltaic cells is converted to AC energy. This enables the photovoltaic system to be quickly set up or relocated, and the collected solar energy from outdoor system can be conveniently delivered to indoor appliances. Techniques to achieve high efficiency at high power delivery through different building structures will be studied for this plug-and-play architecture. In addition, the technique and the system can also be used for non-contact charging of electric vehicles. The transmitter/charger can be placed as a mat on garage floor or parking space. The receiver inside vehicle will pick up the energy delivery through magnetic coupling. This eliminates the need of connecting charging wires to vehicles and exposed metal contacts, which is a safer method of charging electric vehicles **Budget: $**252,000
	Title: An Integrated Sustainable Transportation System **PI:** David Norton, Keith Duncan – UF (Formerly Eric Wachsman (PI) and Shirley Meng (Co-PI);left UF) **Description:** The proposed vehicle, operating on biofuel while in transit and charged by the sun while parked, is the ultimate sustainable transportation system operating completely on renewable American energy resources. Moreover, the use of solid oxide fuel cells (SOFCs) rather than an IC engine in this hybrid vehicle results in a dramatic improvement in efficiency and reduction in emissions. SOFCs are the most efficient technology for converting energy from hydrocarbon fuels to electricity on a "well to wheels" basis. In contrast, the more conventional fuel cells require hydrocarbon fuels to first be converted to H_2, with resultant efficiency losses, followed by losses due to H_2 transport and storage. Therefore, on a system-basis SOFCs hold the potential for producing the least CO_2/kWh from conventional fuels, and if designed to operate on biofuel would in effect be carbon neutral and operating on a renewable resource. *If developed this vehicle would be a transformational change in transportation technology.* **Budget:** $594,000 **External Collaborators:** Solid-State Energy Technology, Inc., Lynntech, Inc., Planar Energy Devices, Inc., CFX Battery, Inc. Back to Thrust 1: Overarching ***This project has been completed***
	Title: PV Power Generation Using Plug-in Hybrid Vehicles as Energy Storage **PI:** J. Shen, **Co-PI:** I. Batarseh - UCF **Description:** The objective of this project is to develop and demonstrate an alternative PV power generation architecture that uses plug-in hybrid vehicle as the energy storage and transfer element with a total system cost target of $3.50/W. The tasks include developing efficient, reliable, and inexpensive maximum power tracking DC/DC battery chargers and 3-phase converters. A 10kW demonstration solar carport charging station will be built on UCF campus. A plug-in hybrid vehicle with a 25kWh battery bank (battery-only driving range of 50-100 miles) and onboard bidirectional AC charging system will be demonstrated **Budget:** $380,816 **External Collaborators:** City of Tavares, FL
	Title: Integrated PV/Storage and PV/Storage/Lighting Systems **PI:** Franky So, **Co-PI:** Jiangeng Xue - UF **Description:** The goal is to increase the efficiency and reduce the cost of solar power through the integration of PV, Li-battery, and LED lighting technologies. Since all components are in the form of thin films, the PV/battery/LED system can be integrated as a single module. Since half of the materials cost of each device is the substrate, integrated module will also reduce materials costs and processing steps. Importantly, their integration further eliminates the need for inverters since they are all low-voltage devices. Such an integrated device can be used to store energy during the day and power the LED panel for lighting in the evening. In addition, we will explore the possibility of fabricating a semi-transparent module. The success of this Task will lead to a novel solar-power lighting panel that can be used as a sky light during the day and a lighting panel during the night without using grid-power. We not only will develop the technologies, but also integrate devices and perform technology-economic evaluation, including life-cycle costs. **Budget:** $576,000 Back to Thrust 1: Overarching

THRUST 5: Ensuring Nuclear Energy & Carbon Constrained Technologies for Electric Power in Florida	
	Title: Reducing Residential Carbon Emission in Florida: Optional Scenarios Based on Energy Consumption, Transportation, and Land Use **PI:** Tingting Zhao**, Co-PI:** Mark Horner - FSU **Description:** In 2007 the Governor of Florida established targets for greenhouse gas (GHG) emissions, which mandate that the State of Florida aims to reduce emissions to 2000 levels by 2017 and to 1990 levels by 2025. To fulfill these goals, not only is the development of renewable sources of energy and fuel needed, but it is also necessary to achieve more sustainable energy and fuel consumption patterns. This project is dedicated to the latter objective, i.e., exploring the effectiveness of optional scenarios for households' consumption of energy and transportation fuels with respect to carbon dioxide mitigation. Human land use is another major concentration of this research, as changes in the built environment and vegetation cover may create sources or sinks of carbon dioxide and hence affect the intensity and origins of carbon emissions. The proposal of this project consisted of three major steps: 1) calculating the Florida baseline carbon dioxide emissions from residential energy and fuel consumption as well as human land uses; 2) developing models of household behavior regarding various energy/fuel conservation and incentive options based on a residential survey; and 3) forecasting energy/fuel demand and CO_2 emission levels in 2017 and 2025 throughout the state of Florida based on the scenarios created in step two. This project was planned to be completed within two years. The PIs concentrated mainly on 1) journal publications on carbon inventory analysis at the state level; 2) finalizing the household energy consumption survey (including sampling design), which is composed of over 30 questions dedicated to household energy practice and responses to energy-saving incentives; and 3) preparation for the external grant application to the NSF Geography and Spatial Sciences (GSS) program. Data collection from the survey is complete and data analysis is underway. **Budget:** $60,844 ***This project has been completed***
	Title: Planning Grant: Enhanced Thermal Performance and Microstructure Simulation of Nuclear Fuels **PI:** Justin Schwartz **-** FSU **Description:**The objective of this proposal was to perform preliminary investigations to determine the viability of improved oxide nuclear fuels through high thermal conductivity coatings such as "BeO." To meet Florida's sustainable energy demands, they pursued the option of enhanced oxide nuclear fuel performance by considering the potential for improved thermal behavior through high thermal conductivity oxide coatings. This work will included a literature search of past investigations of the impact of enhanced thermal conductivity on nuclear fuel and reactor performance, the temperature and irradiation dependence of the thermal conductivity of BeO and other high thermal conductivity oxides, the chemical and thermal compatibility of BeO and nuclear fuels (UO2, PuO2, ThO2 and MOX), and initial studies into BeO coatings on HfO2 particles, where HfO2 serves as a benign surrogate for nuclear fuel oxides. This project is complete. **Budget:** $15,000 ***This project has been completed***
	Title: Biocatalytic Lignin Modification for Carbon Sequestration **PI:** Jon Stewart - UF **Description:** After cellulose, lignin is the second most abundant forma of carbon in plants. Lignin's complex structure makes it difficult to use this material in value-added products, and ahte vast majority of lignin is currently burned to provide energy for factory operations. While burning plant derived lignin does not add to global greenhouse gas levels, having options to remove lignin from the global carbon cycle would lead to diminished atmospheric CO2 levels. This could be accomplished by chemically altering lignin's structure to facilitate long-term terrestrial sequestration or using it in value-added products that would not be discarded immediately. We will use Nature's catalysts (enzymes) to tailor the chemical structure of lignin for both deep-well injection (by using lignin derivatives as drilling "muds") and for materials that can be used in building, packaging, and other manufactured products.) **Budget:** $200,000
	Title: Database Infrastructure for Integrative Carbon Science Research

	PI: Sabine Grunwald. **Co-PI:** Tim Martin - UF **Description:** Rising CO_2 concentrations in the atmosphere and effects on global climate change have been well documented, and future impacts are uncertain but potentially devastating. Florida's natural and agro-forest ecosystems have much potential to sequester carbon in biomass and soils due to unique climatic and landscape conditions. However, research gaps exist to accurately assess carbon pools and fluxes at coarse scales, ranging from county to the region and larger. The overarching objective of this project is to address these obstacles by creating a terrestrial carbon information system (called "TerraC") for the carbon science community, focused on ecosystems in Florida. The information system will be administered through the UF Carbon Resources Science Center (http://carboncenter.ifas.ufl.edu), a multi-disciplinary Center dedicated to research in support of enhanced agricultural and natural resource carbon management. **Budget:** $199,440
	Title: Creation of Carbon Sequestration Data, Technologies and Professional Cohorts for Florida **PI:** Mark Stewart, **Co-PIs:** Jeffrey Cunningham, Maya Trotz - USF **Description:** Rising concerns over increasing levels of greenhouse gases, especially carbon dioxide, have led to suggestions to capture carbon dioxide at fixed sources, such as fossil fuel power plants, and sequester the carbon for millennia by injecting it underground. Florida overlies many thousands of feet of carbonate rocks which may be suitable for geologic sequestration of carbon dioxide. This project will investigate the potential for geologic sequestration of carbon dioxide in Florida, the physical and chemical changes that may occur as a result of injection, assess the potential for escape of injected carbon dioxide, determine the risk, if any, to aquifer systems used for water supplies, develop methodologies for Florida utilities to predict the performance and risks of proposed sequestration projects, and educate a cohort of geologic sequestration professionals to create a carbon sequestration industry in Florida. **Budget:** $479,640 **External Collaborators:** Tampa Electric Company (TECO); Florida Power and Light (FPL); Environmental Consulting and Technology (ECT), Inc.; Los Alamos National Laboratory.
THRUST 6: Florida's Ocean Energy Resources	
	Title: Southeast National Marine Renewable Energy Center **PI:** Susan H. Skemp**, Co-PIs:** Howard P. Hanson, James VanZwieten - FAU **Description**: The research and development program being conducted by the Southeast National Marine Renewable Energy Center (SNMREC) is structured to be the catalyst that will enable the ocean energy industry in Florida toward determining solutions to answer the state's energy challenge. This project focuses on determining the potential of harnessing the ocean current resource and ocean thermal energy conversion (OTEC). The regulatory process both at State and Federal levels continues to evolve as the roles and interdependencies of the individual agencies are more clearly articulated. In addition, knowledge to make these decisions is being defined and targeted on a micro level necessary to assess individual devices. SNMREC's mission is to bridge the gap between concept and commercial deployment of ocean energy technologies by providing at-sea testing facilities for both ocean current and thermal energy research and for technology development. Research cuts across environmental, ecological, resource and technology. **Budget: $8,750,000** **Universities:** UCF, FSU, ERAU, University of Miami, Oregon State University, University of Washington, Pennsylvania State University, University of New Hampshire, University of Hawaii, University of Edinburgh, Heriot-Watt University, Nova Southeastern University, Virginia Polytechnical Institute, Florida Institute of Technology, Embry-Riddle Aeronautical University **External Collaborators:** Numerous industry and State and federal government as well as FFRDCs, such as National Renewable Energy Laboratory, Woods Hole Oceanographic Institution, U.S. Department of Energy, U.S. Department of Interior (Bureau of Ocean Energy Management and Regulation and Enforcement), U.S. Department of Commerce (National Oceanic and Atmospheric Administration), and Florida Department of Environmental, Protection, to name a few.

	Title: Buoy Array for Ocean Wave Power Generation **PI:** Z. Qu, **Co-PI**: K. Lin - UCF **Description:** The objective of this project is to develop a novel design that can extract ocean wave energy for commercial consumption. The design detailed herein is unique in that it is a wave point energy harvester that is small in size and contains all of the mechanical components directly within the buoy. The project focuses mainly on the mechanical system within the buoy as well as methods to control the electrical load on the system. Different mechanical systems have been developed and tested on a motion platform to simulate a vertical wave motion—these systems have been analyzed and compared in order to provide an ever-increasingly effective design. The Harris Corp. have acted as new collaborators with the project since October 1st 2010, funding four UCF senior design teams in the development of a buoy for wave power generation. **Budget:** $150,000 ***This project has been completed***
THRUST 7: Securing our Energy Storage and Delivery Infrastructure	
	Title: The Future Florida Grid: Ensuring a Reliable and Resilient Electrical Energy Transmission and Delivery System in a Changing Environment **PI:** Steinar Dale, **Co-PIs:** T. Baldwin, O. Faruque, J. Langston, P. McLaren, R. Meeker, K. Schoder, M. Steurer - FSU **Description:** The project research goal is to address the challenges of the reliable movement of electrical energy throughout the state as the power system is transformed to include far more renewable and alternative sources, increased use of distributed energy resources (including storage and electric vehicles), emergence of microgrids, possible expansion of new very-large centralized baseload (nuclear), and incorporation of new power conversion, transmission, measurement, communication and control technologies (smart grid). This project has also supported ongoing participation and contributions in national, state, and local power and energy stakeholder groups, including the Gridwise Alliance, the North American Synchrophasor Initiative (NASPI), the American Society of Mechanical Engineers' (ASME) National Energy Committee, the Institute of Electrical and Electronics Engineers (IEEE) Power Engineering Society (PES), Florida's Great Northwest Alternative Energy Advisory Council, and the Tallahassee-Leon Economic Development Council (EDC) Energy and Environment Roundtable. **Budget:** $431,982 Back to Thrust 1: Overarching ***This project has been completed***
	Title: Microgrids for a Sustainable Energy Future **PI:** Chris S. Edrington, **Co-PIs:** Helen Li, Juan Ordonez, Jim Zheng, Mischa Steurer - FSU **Description:** The primary aim of the project was to address research and development in the area of microgrids. Specifically the focus was in the area of PV and Plug in Hybrid Electric Vehicles integration, microgrid modeling and control, grid-tying inverters/converters, energy storage, tri-generation, and standards development for smart grids. **Budget:** $719,333 ***This project has been completed***
	Title: Real-Time Power Quality Study For Sustainable Energy Systems **PI:** U. Meyer-Baese, **Co-PIs:** Helen LI, Simon Foo, Anke Meyer-Baese, Juan Ordonez - FSU **Description:** The main objective of this project is the collection of preliminary data for IESES proposals that can be used to seek local, national and international sources of external funding from private and government sponsors. The overall project has been split up in several independent subprojects to allow a timely completion of the tasks. All tasks have been completed successfully. **Budget:** $15,000 ***This project has been completed***
	Title: Planning Grant: Advancing Knowledge of Network Theory for Analysis and Design of Smart Power Grids **PI:** Svetlana V. Poroseva. **Co-PIs:** Yousuff Hussaini, Per Arne Rikvold - FSU **Description:** With power grids evolving towards increasing size, complexity, and integration, it has become more difficult to describe and predict their behavior, even under normal operational conditions. With

	technological development, climate change, and activities in the political arena, adverse circumstances (natural disasters, intelligent adversary, software design errors, human errors, etc.) have become more probable and costly events. The Project seeks to provide industry and government with advanced analytical and computational tools necessary for the automated evaluation of the structural resilience and reliability of power grids. The potential applications of the Project's results go beyond power grids. Any infrastructure essential to our society and economy (e.g., computer, communication, transportation) can benefit from the Project's results. This project is complete. **Budget:** $15,000 ***This project has been completed***
	Title: Investigating the Effect of Appliance Interface Design on Energy-use Behavior **PI:** Paul Ward**, Co-PIs:** Ian Douglas, David Eccles - FSU **Description:** The primary objective of this research project was to identify the behavioral factors that contribute to energy in/efficiency in the home. In particular, this project was designed to (a) examine current state-of the science on behavioral factors that affect energy efficiency, (b) report on the efficiency of typical energy consuming technology used in the home as well as existing programs designed to improve efficiency, and (b) investigate the types of human-technology interactions and other behavioral factors that lead to in/efficient energy use. To achieve these objectives this project proposed to use laboratory-based experimental and field-based methods to (i) identify interface-design factors that constrain individuals to behave in locally optimal but globally sub-optimal ways, and (ii) survey how cognitive, technological, and motivational behavioral issues affect use in the home environment. **Budget:** $247,720 ***This project has been completed***
	Title: Energy Delivery Infrastructures **PI:** Lee Stefanakos **Co-PIs:** Zhixin Miao - USF (Formerly Alex Domijan (PI) and Arif Islam (Co-PI). Left USF). **Description:** The proposed project is to simulate the effects of a renewable energy generation system in a microgrid context to the distribution grid system. The proposed project is to simulate the combination of renewable distributed generation and a battery system to assess the effects during critical conditions such as power system peak. A research opportunity is to investigate how existing tools can be applied to properly representing dynamic and transient behaviors of microgrids. Therefore, in this project we propose using simulation tools to model a microgrid and investigate how well we can reproduce its measured behavior in the field **Budget:** $485,184
	Title: Micro Battery Defense Development **PI:** Chunlei Wang - FIU **Description:** The microbattery market for new miniature portable electronic devices such as cardiac pacemakers, hearing aids, smart cards, personal gas monitors, micro electromechanical system (MEMS) devices, embedded monitors, and remote sensors with RF capability is increasing rapidly. Thin-film lithium batteries are among the most advanced battery systems that can scale down to the dimensions that match the MEMS devices. However, these two-dimensional (2D) batteries are necessarily thin in order to maintain effective transport of Li ions. In order to power MEMS devices with limited device area (areal "footprints"), batteries must somehow make good use of their thickness. Three-dimensional (3D) configurations offer a means to keep transport distances short and yet provide enough material such that the batteries can power MEMS devices for extended periods of time. In this project, we focus on developing functional 3D microbatteries based on our carbon microelectromechanical systems (C-MEMS) technique. These microbatteries could offer order of magnitude increases in electrode surface area and charging capability than thin film batteries at the same size scale. **Budget:** , $192,418.30 – *Not Funded by FESC*
	Title: Electrostatic Spray Deposition of Nanostructured Porous Metal Oxide Composite **PI:** Chunlei Wang - FIU

	Description: Recently, conversion reactions of interstitial-free 3d metal oxide structures (such as CoO, CuO, and NiO) with structures unsuitable for intercalation chemistry have nevertheless been shown to exhibit large, rechargeable capacities in cells with lithium. The specific capacities of these materials, which are potential candidates for the negative electrode, can be as high as 1,000 mAhg-1 (about three times of commonly used graphitic carbons). However, practical implementation using these metal oxides is hampered by the large capacity loss of the first cycle and poor material cyclability. These problems are partially attributed to the significant volume changes that occur during lithium uptake and removal (molar volume change of ~100%), which causes mechanical failure and the loss of electrical contact at the anode. They are also due to aggregation of metal nanoparticles that appears during the process of discharging the metal oxide anodes. In order to overcome these two challenges and develop excellent rate capabilities and high power densities of Li-ion batteries, metal oxide composite electrodes with hierarchical mixed conducting network structures will be synthesized. We propose the preparation and testing of multi-component metal oxide anode films with a variety of morphologies using a simple and versatile method based on the electrostatic spray deposition (ESD) technique. The ESD technique enables us to reproducibly fabricate thin film ceramic materials with simple, low-cost and controllable designed morphologies. ESD-derived ceramic thin films we obtained including 3-D reticular, spongy-like, hollow sphere, dense, etc morphologies. The structures of these films can be easily tailored by changing the precursor solution component(s) and adjusting the substrate temperature. In this project, we plan to fabricate porous metal oxide materials, MxOy (M=Fe, Co). Material characterization methods (such as: SEM, TEM, AFM, BET, etc) will be used to study the correlation between ESD parameters and surface morphologies. **Budget:** $88,378.711 - *Not Funded by FESC*
	Title: Fabrication and Investigation of Porous Tin Oxide Anodes for Li-Ion Micro Batteries **PI:** Chunlei Wang - FIU **Description:** The requirement of higher energy capacity microbatteries demands the exploitation of new substitute materials with higher energy capacity than traditional graphite. SnO2 has been considered as one of the most promising substitutes for the carbon anode in Li-ion batteries due to its high Li+ storage capacity. However, the practical application of SnO2 as anode is restricted by poor cyclability and rate capability due to large volume change during cycling, which can cause disintegration and electrical disconnection from current collector. In this project, we propose the preparation and testing of tin oxide anode films with a variety of porous morphologies using Electrostatic Spray Deposition (ESD) technique. Our research focus will be developing an ESD processing to fabricate tin oxide electrode with different pore sizes ranging from macropores to mesopores and down to micropores; constructing hierarchical porous tin oxide electrode by controlling process parameters and introducing a surfactant or polymer additives, and material characterization and electrochemical analysis in order to investigate the correlation between morphology and electrochemical performance and understand the underlying mechanism. The proposed research will significantly enhance our understanding of fundamental issues regarding intrinsic properties of porous SnO2 films as anode for Li-ion batteries. **Budget:** $100,000 - *Not Funded by FESC*
	Title: Very High Energy-Density Ultracapacitors **PI:** E. Bakhoum, UWF **Description:** A new type of ultracapacitor that offers a capacitance density on the order of 500 Farads per cubic centimeter or higher has been created. The principle behind the new ultracapacitor structure is the insertion of a 100 nm-thick layer of barium strontium titanate as an interface between the activated carbon electrode and the electrolyte. The new ultracapacitors are highly needed in hybrid vehicle applications; as any significant increase in the energy storage capability of the ultracapacitors leads to substantial improvement in the fuel efficiency of hybrid vehicles. Two manuscripts about this new development were published in 2009. Additional research is ongoing. - *Not Funded by FESC*
	Title: Secure Energy Systems **PI**: Pramod Khargonekar - UF **Description**: The goal of this project is to investigate the concept of secure energy systems and formulate a concrete vision of a broad-based, comprehensive research program. An additional project goal is to develop architecture for modeling, analysis, and design of secure energy systems. An energy system consists of a

	collection of interconnected subsystems representing energy generation devices, energy consumption devices, transmission, distribution, and storage devices, and communications and computing devices. Such systems are dynamic and its operation is influenced by external perturbations. Definition of the system and it environment depends on the problem of interest. This project is motivated by strong interest among key decision makers in understanding and assuring security of energy systems in the face of various natural and man-made threats. Increasing penetration of renewable energy sources and capabilities offered by smart grid have the potential to enhance or degrade security of energy systems. Thus, these new developments present additional motivation for understanding of secure energy systems. Whereas there is an intuitive understanding of security and assurance, much work remains to be done in formulating precise definitions that cover problems of interest and devising an overall architecture that may facilitate a system level analysis and design of such secure energy systems. Taking into account rapid changes in the energy issues in a wide variety of private and public sectors, this project is a proactive effort to develop a vision and architecture for analysis and design of secure energy systems. It is expected that the results of this project will lead to future development and integration of specific analysis and design algorithms and software that will assist system designers in assessing and ensuring an appropriate level of system security. **Budget**: $220,000 Back to Thrust 1: Overarching
	Title: Optimization, Robustness and Equilibrium Modeling for the Florida Smart Grid **PI:** Panos Pardalos - UF Description: This project began in January 2011. It aims to develop algorithms for optimal design and functioning of Florida's next generation of power transmission and distribution systems that will incorporate the new realities of the grid. The goal is to create innovative real time capabilities for 1) optimal location of renewable energy source; 2) detection and prevention of instabilities and outages; and 3) operating models including generalized Nash equilibrium problems in the electricity market. **Budget**: $30,000
Policy	
	Title*:* Economic Impacts of Renewable Energy and Energy Efficiency Policies **PI:** Theodore Kury – UF (PI use to be Mark Jamison) **Description**: To serve its mission and contribute to FESC's fulfillment of its mission, PURC is conducting the three projects described below. These projects will be completed in two years and will deliver policy relevant reports and academic quality papers. The projects are: 1) Economic and Job Impacts of State Renewable Energy and Energy Efficiency Policies This project will provide empirical estimates of state renewable energy and energy efficiency policies on economic development and jobs. 2) Electric Grid Impacts of State Renewable Energy and Energy Efficiency Policies This project will provide an estimate of the impacts of renewable energy policies on the electric grid. It will fill a gap in the literature for Florida, which as to date focused on the impacts on electricity generation. 3) Effects of Energy Commodity Profit Margins on Effectiveness of Energy Efficiency Programs This project will test an assumption that is built into many state energy policies and that is held by many policy makers at the national level, namely that utilities would improve consumer energy efficiency practices if utility prices were decoupled from utility profits. **Budget:** $150,000
	Title: Environmental Impacts of Energy Production Systems: Analysis, Evaluation, Training, and Outreach **PI:** Amy B. Chan-Hilton, **Co-PIs:** Gang Chen, Wenrui Huang, Michael Watts, Ming Ye, Paul Lee - FSU **Description:** The goal of this project is to develop tools and conduct research to objectively assess environmental and water resources needs and constraints while developing prudent energy strategies and policies. The focus of this research will be on fuel cycle and energy production systems. The objectives of this project were to analyze the environmental and water resources demands and potential impacts, specific to Florida's unique geographical challenges, of fuel cycle systems and develop an objective environmental

	impact screening and evaluation tool or decision support system for energy planning and policy making by Florida's industry, utilities, and government. As Florida develops its long-term energy strategy, multiple efforts are ongoing to develop and apply a wide range of energy technologies that are sustainable and carbon-neutral. But pragmatic issues related to environmental impact and sustainability need to be addressed before these technologies may be implemented. This project directly addressed the FESC's Thrust 6 on "Energy systems and their environmental and economic impacts." This project also directly addresses IESES's Objective 4 on unique geographical challenges and Objective 5 on sustainable energy engineering, science and the sustainable energy economy. **Budget:** $118,470 **External Collaborators:** Florida Department of Environmental Protection ***This project has been completed***
	Title: Promoting Energy and Land Use Through Land Use, Transportation and Green Infrastructure Polices **PI:** Tim Chapin, **Co-PIs**: Ivonne Audirac, Chris Coutts, Greg Thompson, Mark Horner - FSU **Description:** In response to the many issues related to energy provision, energy sustainability, and GHGs, in 2007 Governor Crist created an Action Team on Energy and Climate Change. This group was tasked with investigating and recommending strategies for reducing GHG emissions, creating more sustainable energy systems in Florida, and for establishing Florida as an international leader in innovative energy provision. Related to this, the 2008 session saw the Florida Legislature pass HB 697 which, among many things, requires every local government in the state to address energy systems and GHG emissions explicitly within their comprehensive plans. Currently, the linkages between energy planning, environmental and economic sustainability, land use and transportation planning, and GHG reductions have never been stronger in Florida. This project is aimed at continuing the momentum in Florida for developing broad-based solutions to these problems by helping to develop a knowledge base for informing state policy in the areas of energy, sustainability, and land use and transportation planning. **Budget:** $168,185 ***This project has been completed***
	Title: Political and Economic Institutions Regarding Siting of Energy Facilities **PI**: R. Mark Isaac, **Co-PIs:** Douglas Norton, Svetlana Pevnitskaya - FSU **Description:** The "Hold-Out" project evaluates the "hold-out" concept, which is discussed repeatedly in the context of public policies regarding land acquisition and facilities siting, but a clear definition is elusive. To economists, the most likely definition is that a profitable amalgamation of land parcels by one buyer from competing sellers does not occur because of the failure of the private bargaining process. However, sometimes the term seems to be used more for delay instead of failure in bargaining, or even the very different concept of creation of any bilateral bargaining situation of the buyer and the "last" or "holding-out" seller, which may be inconvenient to the buyer but is immaterial in terms of economic efficiency unless efficient trades actually fail. The experimental design is complete, the programming is complete, Institutional Review Board approval has been obtained, and we have conducted two complete experimental treatments. This research was presented at one of the Presidential Sessions at the 2009 Meetings of the Southern Economics Association in November in San Antonio. **Budget:** $79,621 ***This project has been completed***
	Title: Experimental Investigation of Economic Incentives of Policies, Institutions and R&D in Environmental Conservation **PI:** Svetlana Pevnitskaya, **Co-PI:** Dmitry Ryvkin - FSU **Description:** Policies and institutions aiming at reducing pollution and battling climate change often do not reach desirable results because actual decisions of governments and economic agents deviate from those predicted by theory. We employed methods of experimental economics to find and explore such deviations and their causes, and used the findings to modify theory and design better policies and institutions. In this project, we constructed a theoretical model of decisions in a dynamic environment with costs of pollution and climate change, while testing the theory in laboratory experiments with human subjects. We studied actual behavior and explore responses to changes in the environment, production technologies, investment in clean technology and institutions. This project is complete.

	Budget: $43,217 ***This project has been completed***
	Other
	Title: Fusion Energy Spheromak Turbulent Plasma Experiment-STPX **PI:** Charles A. Weatherford, **Co-PIs:** Kyron Williams, Ephrem Mezolin - FAMU **Description:** The Florida A&M University's Center for Plasma Science and Technology (CePaST) has nearly completed the construction of a spheromak fusion reactor. A spheromak is one of a general class of experiments used to investigate key plasma physics principles relevant for the development of magnetically confined, controlled thermonuclear fusion as a source of electrical power. This project involves collaboration between Florida A&M University CePaST, West Virginia University, and Auburn University. The spheromak turbulent plasma physics experiment (STPX) is being constructed at FAMU in a facility especially built for the STPX experiment. Fusion research is a key element in the nation's long term energy supply strategy, The spheromak concept may be a possible alternative to the tokamak concept (deployed at ITER) which affords access to fundamental fusion science issues supportive of fusion while allowing us to maintain and nurture an American fusion scientific workforce. This project will determine, using a fast duty cycle between theory, experiment, and simulation, the essential elements required for full kinetic modeling of an entire spheromak plasma using ab initio MHD with direct modifications from new turbulence physics. The project will focus on the management of fluctuations and transport in a spheromak plasma using new turbulence physics models and comprehensive helicity control. We will employ high time- and spatial-resolution measurements of electron temperatures, ion temperatures, and magnetic field fluctuations to investigate, understand, and eventually control reconnection driven heating as a means of increasing the plasma temperature of spheromak plasmas. We will use divertor diagnostics of radiation and particle transport along with edge biasing for electric field control to explore the effects of driven flows on confinement and heating in spheromak plasmas with microparticles and will investigate the effects of MW pulses coupled to protons on the plasma current and confinement. **Budget:** $950,000 – *Not Funded by FESC* **Universities and External Collaborators:** Dr. Earl Scime, West Virginia University Dr. Ed Thomas, Auburn University Dr. Simon Woodruff, Woodruff Scientific, Inc
	Title: Marketing Strategies to Incentives Entrepreneurship and Innovation in the Development of Sustainable Energy **PI:** Joe Cronin - FSU **Description:** The objective of this project was to investigate the role of market pull strategies in advancing sustainability goals. Specifically, the intent is to identify what "drives" consumers' attitudes and behaviors relative to sustainable products. This includes consumers' personal attitudes, opinions, and beliefs, their perceptions of their own and organizations' abilities to affect or change the environment in which they live, and their personal characteristics (e.g., demographics). In addition, in collaboration with the College of Communications, the strengths and weaknesses of the various communication modalities that can be used to deliver sustainability knowledge to consumers (e.g., advertisements, testimonials, expert word-of-mouth communications, public relations, publicity, etc) were assessed. Specifically, the research attempts to identify the optimal market pull modality; that is, the means by which to deliver to consumers the knowledge that drives the purchase of sustainable goods and services. The overall objective of the research is to provide much needed market pull information for organizations embarking on "green" marketing strategies; that is, firms in the process of developing or expanding their mix of environmentally friendly goods and services. **Budget:** $191,555 ***This project has been completed***
	Title: Energy Sustainable Florida Communities **PI:** Richard Feiock, **Co-PIs:** Ivonne Audirac, Keith Ihlanfeldt - FSU

	Description: The objective of NESC is to stimulate innovation and energy investments that will accelerate energy savings by local governments by sharing best practices and organizing and managing large scale collaboration and bulk buying projects. Florida State University has been working with U.S. DOE contributing surveys, research and outreach assistance to assist in efforts to promote investment, collaboration, and bulk purchasing by local governments that will achieve significant cost savings. This includes organizing NESC conference calls co-hosted by hosted by FSU and DOE, conducting several surveys, and hosting a meeting of Florida local government EECBG sub-awardees. These initial research efforts and conference calls have been successful in identifying broad interest in collaboration and bulk buying. They also revealed significant barriers to collaboration that need to be addressed including issues related to coordination within governments, among governments and with other organizations. We are now undertaking activities to address these barriers to collaboration at three levels: First we are conducting focused regional workshops throughout the state. By bringing interested governments in each region together with experts in collaboration, governance, finance, and purchasing we will identify specific projects and design the mechanisms to put the projects in place. Second, are expanding our statewide dialogue on a more systematic basis and share the insights and successes of our regional workshops. Third, we are working with universities and other partners throughout the U.S. to share strategies and insights and help replicate our successes in other states. By expanding our efforts and formalizing the network we will make large scale energy savings a reality. **Budget:** $125,424 ***This project has been completed***
	Title: Development of a Renewable Energy Research Web Portal **PI:** Charles R. McClure, **Co-PIs**: Ian Douglas, Chris Hinnant - FSU **Description:** This project identified, organized, and made available via a web portal, research generated as part of the FESC effort as well as other selected related information resources and tools as identified by FESC participants. The goal of this project was to provide IESES, FESC, researchers, and others in the state of Florida with the research information they need to accomplish statewide energy goals. An initial product from this project was an operational web portal that identifies, organizes, and provides access to a range of FESC and other research related to renewable and alternative energy information. A second product was research results on extending technologies that allow users to share information and grow/sustain the web portal through a range of social networking techniques. This research attempts to position FSU to seek additional external funding related to interactive databases and web portals. The ultimate expected outcomes resulting from the project include increased IESES and FESC researcher productivity; increased leverage and collaboration of FESC resources and funding; and improved policy- and decision-making regarding the future uses and development of renewable and alternative energy in Florida. **Budget:** $194,542 ***This project has been completed***
	Title: Planning Grant: Hydrogen Storage Using Carbon-Based Adsorbent Materials **PI:** Efstratios Manousakis - FSU **Description:** This project was a theoretical investigation of a variety of carbon based nano-porous materials, such as activated carbon or single-wall or multi-wall carbon nanotubes, which can be used to store and transport hydrogen. We find that by doping with metallic elements, the micro-surfaces of these carbon-based porous materials provide increased van der Waals forces to the adsorbed hydrogen molecules; this effect significantly enhances the volumetric energy density for hydrogen storage and we caried out a full theoretical investigation to find the optimum conditions. This project is complete. **Budget: $15,000** ***This project has been completed***

Education and Outreach	
	Title: Florida Advanced Technological Education Center (FLATE) **PI:** Marilyn Barger - UF **Description:** FLATE (Florida Advanced Technological Education Center) is FESC's partner to develop statewide curriculum frameworks for technical A.S./A.A.S. degree programs supporting existing and new energy business sectors. FLATE develops the frameworks and facilitates their progress through the multiple sequential industry-validation, student competencies based, FLDOE procedure. FLATE also develops new courses and provides faculty professional development as required for each new program of study. Additionally FLATE helps colleges in the State College System implement the new frameworks in their institutions. To support the new curriculum, FLATE will work closely with the FESC Public Outreach and Industry Partnership programs to provide additional professional development opportunities for teachers and faculty to upgrade and update their STEM knowledge base. **Budget:** $300,000 **External Collaborators:** Brevard Community College; Tallahassee Community College; Daytona State College; Central Florida Community College; Polk State College; Florida State College at Jacksonville; Valencia Community College; School District Hillsborough County; Florida Department of Education – Division of Adult and Career Education; West Side Technical School; WFI Banner Center for Energy; Advanced Technology for Energy and Environment Center (ATEEC); University of West Florida, Dept of Construction Technology; WFI Banner Center for Construction; WFI Banner Center for Alternative Energy; USF College of Engineering; Madison Area Technical College ATE project for Alternative Energy certifications; Milwaukee Area Technical College Energy Conservation and Advanced Manufacturing Center (ECAM); Florida Energy Workforce Consortium (FEWC); TECO; Progress Energy; ISTEC (Ibero Science and Technology Education Consortium).
	Title: Outreach Activities for FESC **PI:** Pierce Jones, Kathleen C. Ruppert, Hal S. Knowles III, Nicholas Taylor, Barbra Larson, Craig Miller- UF **Description:** Developing educational outreach programs and materials designed to deliver practical, applicable information and knowledge on energy-related topics to the general public as well as targeted to specific audiences such as builders, planners, engineers, architects, small businesses, local governments, and utilities through the Cooperative Extension Service and others. By focusing educational programming on climate and efficient use of energy and water, the program aims to provide the knowledge needed by building and energy professionals, local governments, and the general public, to significantly reduce greenhouse gas emissions in Florida. **Budget:** $497,670 **External Collaborators:** Primarily DCA, FSU, UCF (FSEC), USF, and DEP with many others as well.
	Title: UFTR Digital Control System Upgrade for Education and Training of Engineers and Operators **PI:** Gabriel Ghita – UF (PI use to be Alireza Haghighat; he has left UF) **Current PI:** Kelly Jourdan **Description:** The goal of this project is to contribute to a major initiative on design, licensing and construction of a fully digital control system for the University of Florida Training Reactor (UFTR). This makes the UFTR the first operating nuclear power plant in the United States that uses a fully digital control system. This facility will provide for the training and education of the necessary workforce in the area of digital control and instrumentation for nuclear reactors. With this effort, a new focus/certificate on digital control and instrumentation will be developed at the Nuclear and Radiological Engineering (NRE) Department. Further, the UFTR facility will offer training courses for community colleges (Central Florida, Indian River, and Jacksonville) in the State of Florida, personnel from nuclear utilities and government agencies including the Nuclear Regulatory Commission (NRC). The project has already received significant funding from industry and government in form of grants, contracts, equipment/systems, and engineers' time. **Budget:** $308,000 **Curent Budget:** $45,000 **External Collaborators:** Several engineers from AREVA NP Inc & Siemens Corporation

	Title: Energy and Efficiency Video Public Service Announcements **PI:** Andy Opel, **Co-PIs:** Phil Steinberg, Leslie France-Patterson, Laura Arpan, Ian Weir - FSU **Description:** This interdisciplinary team produced 6-8 short (30-second/one-minute) video public service announcements (PSAs) that address issues of energy and efficiency and one 12-15 minute informational documentary targeted to Florida legislators and the Governor's office. These videos will be tailored to reinforce existing IESES efforts. **Budget:** $200,720 ***This project has been completed***
	Title: Planning Grant: Climate modeling and Outreach Activities **PI:** Shawn R. Smith, **Co-PIs**: Steve Cocke, David Zierden, James O'Brien, Julie Harrington - FSU The objective of the planning grant is to develop at least one external funding proposal that focuses on areas of climate modeling and/or climate outreach that support the activities of the IESES. The focus of our activities has centered on evaluating the potential offshore wind resource in the northeastern Gulf of Mexico and elsewhere in Florida's waters. Preliminary research has been completed using observations from instrumented Air Force towers and buoys in the waters around Florida. The existence of wind power capacity has been identified at the assessed locations. Due to the sparseness of in-situ wind data in the region, a numerical modeling approach will need to be pursued to develop a wind climatology with sufficient spatial and temporal scales to further define the offshore wind power capacity. A vast portion of the work conducted focused on outreach and education. When we began our project, the idea of offshore wind power in Florida was not even on the radar of the Florida Legislature or the renewable energy sector at large. We worked to raise the visibility of offshore wind as an energy resource for Florida by attending meetings, connecting with the wind power industry in Florida, and briefing two members of the Florida Legislature and presenting to the Florida Energy and Climate Commission. As a result of these connections, we submitted a preliminary proposal to Siemens Wind Power and have developed a network of colleagues both within FSU and the private sector that are interested in further developing Florida's offshore wind resource. **Budget:** $15,000 ***This project has been completed***
	Title: Visiting Law Professor **Principal Investigator:** JB Ruhl, Jim Rossi **Co-PI:** Uma Outka - FSU **Description:** Two-year Visiting Scholar, Uma Outka, at the College of Law researched the interface between land use law and innovative energy solutions and delivering academic symposia and graduate student seminars on the research scope, comprising Sustainable Energy Research Project (SERP) within Environmental and Land Use Law Program. This project is complete. **Budget:** $214,603 ***This project has been completed***
	Title: Energy Sustainability Course **Principal Investigator:** Mark Jamison - UF **Description:** This project creates the course GEB 4930 Energy Sustainability as a general business class. It examines issues in energy sustainability that confront policy-makers and managers around the world. It also covers energy utility markets and regulation, challenges in addressing environmental externalities, methods for encouraging environmentally friendly energy solutions, and the hard realities of the economics and science of energy. The capstone is a research paper that examines alternative energy futures for the State of Florida. Top papers will have the opportunity to participate in a moderated forum sponsored by the Bob Graham Center for Public Service focused on Energy Sustainability in Florida. The course will be videotaped and made available to non-UF students in 2015. **External Collaborators:** NA **Status: Active**

	Title: Buildings and Energy: Design and Operation Vs. Sustainability"- An Energy Engineering Course for Florida-specific Building Design & Operation **Principal Investigator:** Prabir Barooah - UF **Description:** To achieve higher standards in building design and operation, a solid foundation of energy engineering and sustainability principles is essential. At UF engineering, there are no courses offered to students and industry professionals in energy topics particularly related to buildings, specifically for the design and operation in Florida climate conditions. This project fills this void through the development of an energy engineering course. **External Collaborators:** Dr. Timothy Middelkoop, University of Missouri **Status: Active**
	Title: Renewable Energy Education Program at USF's Patel College of Global Sustainability **Principal Investigator:** George Philippidis - USF **Description:** The goal of this project is to establish an education program in renewable energy at USF's Patel College of Global Sustainability (PCGS) by developing two graduate-level courses: (1) "Renewable Transportation Fuels" and (2) "Renewable Power Portfolio". The courses will be developed for both in-class and on-line delivery and will constitute the concentration in Renewable Energy for the College's existing M.A. in Global Sustainability. **External Collaborators:** NA **Status: Active**
	Title: Introducing Specialization in "Sustainable Energy Systems" for Under-Graduate Students in Engineering at the University of West Florida **Principal Investigator:** Bhuvana Ramachandran and Co-PI: Muhammad Rashid, UWF **Description:** The specialization in "Sustainable Energy Systems" initiated at the University of West Florida is a collaborative effort among faculty in the Department of Electrical and Computer Engineering and Department of Ethics, Law and Policy at the University of West Florida. The objective is to facilitate an understanding of the technology, processes, economics and policy that underpin energy systems within the context of the sustainability of energy supply and demand. **External Collaborators:** NA **Status: Active**
	Title: A Certificate Program to Enhance Sustainable Behavior Change Competencies for Energy---Focused Educational Outreach Professionals **Principal Investigator:** Laura A. Sanagorski Warner - UF **Description:** The aim of this educational offering is to improve the process of program delivery focused on sustainable behavior change within the context of energy usage. **External Collaborators:** NA **Status: (Recent award)**
	Title: Solar Energy Technologies: Fundamentals and Applications in Buildings **Principal Investigator:** Cheng-Xian (Charlie) Lin - FIU **Description:** In this project, the PI at Florida International University will develop a new online course in solar energy technologies, with emphasis on solar applications in buildings, taking account the unique solar resource and infrastructure in the state of Florida. **External Collaborators:** NA **Status: Active (Recent award)**
	Title: Renewable Energies and Sustainability Education **Principal Investigator:** Ryan Integlia and Sesha Srinivasan - Polytech **Description:** This education proposal is aimed at developing a stand-alone course content accessibility, conducting competitions and workshop that can be offered to undergraduate and graduate students at the Florida Polytechnic University. **External Collaborators:** NA **Status: Active (Recent award)**

FESC Phase 2 Technology Commercialization	
	Title: Development of a Low Cost Concentrating Solar Energy System Using Solar Sausages **PIs:** David VanWinkle, Sean Barton – UF **Description:** Beginning in late 2010, weekly meetings have been held at HHH offices in Tallahassee that include representatives of the several entities involved in deploying the "Solar Sausage" concentrating system at the Yulee St. site in Tallahassee. The entities include Pro Solar Inc., Barkley Consulting Engineers Inc., Winton Engineering PA, and Applied Research and Design Inc. A series of 50-foot long prototype sausages were made and inflated on site. Many issues were identified that needed to be resolved before manufacturing and deploying several hundred solar sausages on site including methods of constructing, mounting, and operating the balloons, distribution of air and electricity, and removal of heat. **Industry Partner:** Hunter and Harp Holdings (HHH)
	Title: Stress Evolution in Solid-State Li-Ion Battery Materials **PI:** Kevin S. Jones – UF **Description:** Li-ion battery (LIB) technology is promising for use in electric drive vehicle (EDV) and stationary energy storage applications. However, challenges with materials safety, performance, cost, and manufacturing scalability have largely prohibited LIB implementation in these situations. Challenges in stress evolution during the fabrication and processing of the elements of the cells remain and are not well understood. In this study the roles of component fabrication and processing conditions on the resulting stresses in the materials are being evaluated. Thin film battery components will be deposited on stainless substrates using a novel fabrication method invented and patented by Planar Energy and the components will be subjected to different annealing treatments. A novel curvature measurement system will be used to characterize the stress in the component layers both after deposition and annealing and structural analysis techniques will be used to correlate the resultant component material microstructure and crystallographic phase(s) with the measured stresses. **Industry Partner:** Planar Energy
	Title: SWNT Based Air Cathodes for Fuel Cells & Metal Air Batteries **PI:** Andrew G. Rinzler – UF **Description:** The goal of this project is to develop and use novel gas diffusion oxygen reducing electrode (air cathode) based on single wall carbon nanotube (SWNT) films in zinc-air batteries and fuel cells. Metal-air batteries, utilizing surrounding air as an inexhaustible cathode material have the highest specific and volumetric energy density of any primary battery system available. Gas diffusion oxygen electrodes, where molecular oxygen is electrocatalytically reduced, are vital to battery and fuel cell performance. The air cathode should be permeable to air or another source of oxygen, but must be substantially hydrophobic so that electrolyte will not leak though it, and have an electrically conductive element connected to external circuitry. Generally, conventional air cathode is a thick multilayer film comprising carbonaceous powder mixed with nanoscale metal catalyst to promote oxygen reduction and hydrophobic polymer additive pressed onto electrically conductive layer. While noble metals such as platinum that are commonly used as catalysts in conventional air cathodes offer the advantages of intrinsic catalytic activity, their deficiency in resource, high costs, and susceptibility to catalyst poisoning, have become a serious concern for commercial applications. An optimized SWNT based air cathode catalyst that would constitute a significant improvement in existing technologies is being developed. This new system avoids precious metals, is not poisoned, is thin, light-weight, and resists electrolyte flooding. **Industry Partner:** nRadiance LL

	Title: Uni-Directional Impulse Turbine for the Powering of Offshore Monitoring Systems **PI:** Zhihua Qu, **Co-PI:** Kuo-chi Lin – UCF **Description:** Numerical modeling and experimental testing of turbine for wave energy conversion. The University of Central Florida and Harris Corporation have joined efforts to design, build and analyze a wave powered abandoned oil well monitoring system for use in the Gulf of Mexico. This system proposes a fully automated oil leak detection system which is self-powered by the local ocean energy which is converted to electricity, conditioned and sent from the surface buoy to the ocean floor to supply power for an abandoned oil well monitoring system. **Industry Partner:** Harris Corporation

APPENDIX B – FLORIDA UNIVERSITY SPIN-OFF COMPANIES

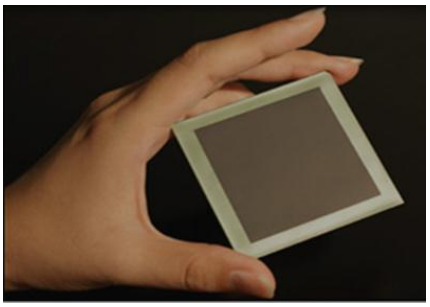
#	University	Name of Business	Location	Start-Up Date	Specialty	# of Employees
1	FSU	Bing Energy International	Tallahassee, FL	2010	Fuel Cells	10 in US and 30 in China
2	FSU	General Capacitor	Tallahassee, FL	2012	Super Capacitors	1
3	FSU	High Performance Magnetics	Tallahassee, FL	2008	Cable-in-Conduit (CIC) magnet components	10-20
4	FSU	SunnyLand Solar, LLC	Tallahassee, FL	2011	Solar Collectors	2
5	UCF	Garmor, Inc.	Orlando, FL	2012	Edge-Functionalized Graphene Oxide	8
6	UCF	HybridaSol	Orlando, FL	2012	PV-TE Hybrid	4
7	UCF	HySense Technology, LLC	Rockledge, FL	2012	H_2 Sensing Tape	3
8	UCF	TALAWAH Technologies	Orlando, FL	2012	H_2 Sensors	3
9	UCF	Helicon Chemical Company	Orlando, FL	2012	Self-cleaning coating chemicals and oxidative fuel additive	5
10	UF	Energy Efficiency Company*	Greenville, SC	2009	Energy Efficiency – Turbines	5 to 10
11	UF	Florida FGT, LLC	Gainesville, FL	2010	Energy Crops	1
12	UF	Florida Sustainables	Gainesville, FL	2010	Chemicals from Biomass	2

13	UF	US Bioplastics	Gainesville, FL		Water-degradable Plastics from Feedstock Waste	5
14	UF	NanoPhotonica, Inc.	Longwood, FL	2010	Next Generation Optoelectronic Devices	5
15	UF	Compressor Company*	Houston, TX	2010	Air and NG Compressors	5 to 10
16	UF	Fuel Cell Company*	Fulton, MD	2010	Solid Oxide Fuel Cells	5 to 10
17	UF	Solar Fuel Company*	Gainesville, FL	2012	Chemicals to H_2	1
18	UF	Solar Powder	Gainesville, FL	2011	Nanoparticle Thin Film Photovoltaics	1
19	UF	Innovative Space Tech. LLC	Orlando FL	2014	Solar	3
20	UF	Evident Energy Ltd	Gainesville FL	2014	Software as service	4
21	UF	TransformAir Inc.	Tampa, FL	2013	Energy efficient air filter	2
22	USF	MudPower	Lutz, FL	2013	Fuel-Cells Modular Power Sources	2
23	USF	Trash 2 Cash-Energy, LLC	Tampa, FL	2011	Landfill Gas to Liquid Fuel	2
24	USF	SunBorne Energy	Delaware Corp.	2010	Solar installations in India	11+
25	USF	New Energy Technologies Inc.**	Columbia MD	2009	SolarWindow™ Technology	**
	Companies Formed but not Survived					
26	UCF	*Almos Battery Corp.*	*Orlando, FL*	*2011*	*Grid Scale Battery (Low Temp Molten Salt)*	*0*
27	UCF	*Mesdi Systems, Inc.*	*Orlando, FL*	*2011*	*Electrospray (for Batteries, FC, etc.)*	*0*
28	UCF	*CeramiPower*	*Orlando, FL*	*2011*	*CHP*	*0*

29	UCF	*PV Integrated*	*Cocoa Beach, FL*	*2011*	*Thin Film PV*	*0*
30	UF	*UB-WiSystems, Inc.*	*Gainesville, FL*	*2012*	*Low Power Wireless Transmission*	*0*
31	UNF	Omnii Sense, LLC	*Jacksonville, FL*	*2011*	*Intelligent Sensor Network for Street Light Efficiency*	*0*
32	USF	*Energy Management Professionals*	*Lutz, FL*	*2008*	*HVACR*	*0*

** Company name kept confidential due to university licensing*
*** New Energy Technologies Inc. is not a university spin-off. They licensed USF technology*

Bing



Fuel Cell Company

From Biomass to Biodegradable Plastics

SunnyLand Solar, LLC, Solar

Description of Florida University Spin-Off Companies

Bing Energy International (Tallahassee, FL – FSU Technology)
http://bingenergyinc.com/ - By utilizing a revolutionary carbon nanotube based solution, Bing Energy International (BEI) has developed a product and process that maximizes the effectiveness of the platinum catalyst required for PEM fuel cells. PEM fuel cells are relatively low temperature devices that can be used in a wide variety of applications ranging from backup power, to automotive power, to stationary power generation. The result is equal or better electrical output, from only 30% of the platinum and with increased durability. This technology has been independently verified to meet nearly all of the Department of Energy's hydrogen fuel cell goals for the year of 2015.

General Capacitor (Tallahassee, FL – FSU Technology)
http://www.news.fsu.edu/More-FSU-News/Florida-State-inks-deal-to-license-new-supercapacitor-invention
General Capacitor LLC is a privately held company and was founded in 2012 to manufacture advanced Li-Ion capacitors.

High Performance Magnetics (Tallahassee, FL – FSU Technology)
http://ciceft.com/ - High Performance Magnetics designs, fabricates and tests advanced cable-in-conduit (CIC) magnet components. CICs are typically used in large-bore, fast-ramping superconducting magnets for high-tech applications such as Magnetically Confined Fusion Energy, High-Field Magnet Laboratories, Spallation Neutron Sources, and Superconducting Magnetic Energy Storage devices.

SunnyLand Solar, LLC (Tallahassee, FL – FSU Technology)
http://www.research.fsu.edu/techtransfer/solarsausage.html - SunnyLand Solar is developing a new solar technology licensed from Florida State University called the "Solar Sausage". This technology has the potential of dramatically reducing the cost of concentrated-solar applications. Material cost, ease of manufacturability, optical quality, and speed of deployment are just some of its benefits. It is an inflatable made of durable Mylar and has been shown to tolerate UV radiation and routine high winds. SunnyLand, as sole licensee, has already deployed over 2,300 these units in North Florida and with determination continues to work on improvements to this burgeoning technology.

Garmor Inc., (Orlando FL – UCF Technology)
http://garmortech.com/ - Garmor has developed a simple yet effective method of producing edge-functionalized graphene oxide. Whereas traditional methods have relied upon powerful oxidizing agents and acids to produce graphene, Garmor relies upon new advances in milling technology to produce graphene oxide yielding only water as a by-product. These proprietary achievements eliminate hazardous waste disposal costs and deliver a product suitable for large scale production at commodity-type prices.
Graphene/graphene oxide has already been shown to have wide applications as an adsorbent, lubricant, corrosion inhibition, electrodes, transistors, and as an additive used to strengthen composite materials. Garmor's manufacturing technology has been designed to tailor the oxidation level so that it can be uniquely matched to a given application. For example, Garmor's moderately oxidized, edge-functionalized graphene oxide is fully dispersible in water and can be deposited in thin films. This offers the potential for improved electronic displays, solar cells, water-based

lubricants, and various hydrophilic polymer composites. Garmor's graphene can also be readily functionalized to accommodate non-polar environments.

HybridaSol, (Orlando FL – UCF Technology)
http://futureenergy.ultralightstartups.com/campaign/detail/809 - Reduced PV degradation and increased PV output are achieved with a ThermoElectric (TE) cell printed on the substrate of the PV cell, then operating the TE cell as a Peltier cooler powered by the PV cell itself. Though diversion of any PV output seems self-defeating, favorable gains in net energy production are achieved by exploiting the large differences in the PV temperature-degradation curve (%Voc/oC) and the heat transport curve (Energyelectric/Energyheat) of the TE cell. Note the very short distances this heat must be transferred, from the PV wafer to the backplane (< 1 mm), and it becomes apparent very little parasitic energy is required from the PV cell. The economics then become attractive, provided the TE materials and process for manufacture of the PV-TE Hybrid are low cost. HybridaSol won a NSF Phase 1 SBIR award and secured new management to run the company and production development. They now have 4 employees.

HySense Technology, LLC, (Rockledge FL – UCF Technology)
http://megawattventures.com/2013finalists/hysensetech/ - Manufactures chemochromic (color-changing) pigments for flammable gas leak detection applications. HySense Technology, LLC believes that in the current and future national energy portfolio, hydrogen and natural gas are two of the most important energy resources. However, keeping such flammable gases contained to establish a safe environment for producers and end utilizers is of utmost importance. Presently, the large majority of gas leak detection systems have been focused on the development of electronic sensors. Electronic sensors have several drawbacks including loss of sensitivity in the field due to the environmental effects, costs, and problems associated with power required on-site. Thus, a visually easy to detect leak detector can greatly enhance the market acceptance and expansion of these valuable energy sources. HySense won CAT5 Awards recently and received $100K funding from the program. They have also received a R&D 100 Award, and has sales with large customers – major utilities, GE, etc.

TALAWAH Technologies (Orlando FL – UCF Technology)
http://www.talawahtechnologies.com/ - TALAWAH Technologies develop wireless hydrogen sensors and a proven communication system that all consume little battery power for detecting physical characteristics in complex environments. TALAWAH Technologies is founded on joint research conducted at the University of Central Florida and the National Aeronautic and Space Administration at Kennedy Space Center. TALAWAH Technologies has commercialized the coherence multiplexed transceiver (CMT) for communication with surface acoustic wave (SAW) sensors. This partnership lead to the invention of the coherence multiplexed SAW sensor system in 2012 and demonstrated a working matrix of SAW sensors that were able to read temperature and range data at distances over 20 meters. Talawah is a pivoting company and have picked up a strong sensor expert mentor recently to identify new opportunities.

Helicon Chemical Company (Orlando FL – UCF Technology)
http://www.heliconchemical.com - This Orlando, Florida Company is transforming recent advances in nanotechnology into commercial products. Their first products are a set of nanoparticle ingredients for high-energy fuels and propellants for the aviation and aerospace industries. Helicon's products promise to increase safety, efficiency, and performance, and reduce environmental impact compared to the conventional jet and rocket fuels and propellants. The technology and founders are from the University of Central Florida. Helicon won 2 Phase 1 SBIRs (from Navy and AirForce), and have a contract with Aerojet Rocketdyne. They now have 5 employees.

Energy Efficiency Company (Anderson, SC – UF Technology)
http://www.emerald-endeavors.com/ - Company's second generation SMART gas sensors are thin-film based gas sensor for combustion applications. Transduction of the analyte composition and concentration is realized through impedance based measurements of an oxide electrode in a solid electrolyte electrochemical cell.

Florida FGT. LLC (Gainesville FL – UF)
http://www.floridafgt.com/ - Florida FGT provides professional advice to forest and agricultural landowners on various aspects of the use of fast-growing Eucalyptus, Corymbia, Populus, Taxodium, and Pinus species.

Florida Sustainables (Gainesville, FL – UF Technology)
http://gainesvillebizreport.com/cade-prize-winners-look-to-revolutionize-plastics/ - Florida Sustainables innovates and markets sustainable materials, especially biorenewable and degradable polymers designed to replace petroleum-based plastics. The company synthesizes polymers called polyesteracetals, providing the strength of petroleum-based plastics lacking in other "green" plastics made from PLAs — or polylactic acid. Their plastics stand up to heat better than current "green" plastics and are not brittle and noisy such as the bag of SunChips abandoned due to consumer complaints. They also degrade within five to 10 years of their usable life compared to 1,000 years for petroleum plastics, and they do not require the composting conditions of PLAs to break down.

US Bioplastics (Orlando FL – UF Technology)
US Bioplastics, an Orlando-based company that takes feedstock waste, paper production by-products, or other plant waste to practical use and then returns it to the environment without damaging the ecology. US Bioplastics' flagship product Gatoresin™, based on technology licensed from the University of Florida, is a bio-renewable, water-degradable plastic designed for use in highly disposable applications. Gatoresin eliminates the possibility of environmental contamination by replacing non-degradable petroleum-based plastics with materials derived from agricultural and other waste products.

Compressor Company (Houston TX – UF Technology)
http://www.oscomp-systems.com/ - They deliver turnkey solutions that enable customers to transition to natural gas as an energy source, even if they do not have access to a pipeline. They successfully delivered commercial quantities of gas to a disconnected user. They are developing game-changing compression technology capable of efficiently compressing wet gas and multiphase streams to compression ratios that are an order of magnitude higher than existing technology.

NanoPhotonica, Inc. (Gainesville, FL – UF Technology)
http://www.nanophotonica.com/ - NanoPhotonica is developing breakthrough nanomaterials, production techniques and associated products that will enable market-altering improvements to optoelectronic products. The company is developing a number of innovations that will transform both the flat panel display and solar panel/green energy sectors. For example, smartphones and camera displays will be able to operate with 50% less power than traditional LCDs. In addition, the production costs are anticipated to be 75% lower than display competitors, while still providing more vivid colors and greater ease of viewing. For display applications, the company's patented, all-solution-processable quantum dot light-emitting diodes technique (S-QLED®) allows fabrication of displays using ink-jet printing methods.

Fuel Cell Company (Fulton, MD – UF Technology)
http://www.redoxpowersystems.com/ - The company was formed in 2012 by a group of scientists and engineers with extensive research, technical and managerial experience. They are pioneering major breakthrough Solid Oxide Fuel Cell technology. It is their solution for Distributed Power Generation and Transportation.

Solar Fuel Company (Gainesville, FL – UF Technology)
http://www.linkedin.com/pub/kevin-bowles/3/b76/b9 - This is a high growth, solar, biofuels (non-biomass) company that uses a proprietary low pressure/high temperature thermochemical process and proprietary reactor to convert solar energy, water and CO_2 into fuel (hydrogen or syngas). Solar Fuel: 1) has a flexible, mobile footprint accommodating varying locations, 2) zero carbon footprint and 3) produces cost competitive, (non-subsidized) fuel. Solar Fuel has raised (late 2011) $3MM from the DOE, $35K from the University of Florida and completed a bench prototype. Solar Fuel is currently scaling the product and is in discussions with potential strategic partners including oil and gas, defense, utility, states and neighboring nations.

Solar Powder (Gainesville, FL, UF Technology)
http://www.research.ufl.edu/otl/pdf/startup/Solar_Powder_COS.pdf - Solar Powder is a solar-energy company that has developed an innovative technology that will set a new low cost point for solar energy. The technology behind Solar Powder uses CIGS, a semiconductor absorber layer composed of copper, indium, gallium and selenium. CIGS was chosen because of its high cell efficiency, high energy yield, and now with Solar Powder, its low cost of manufacturing when compared to other semiconductor material, such as crystalline. Solar Powder has developed a process for the synthesis of the CIGS absorber layer that addresses the major manufacturing cost factors challenged by other CIGS methods. This includes a proprietary nano-powder that is mixed with a secret Solar Powder solvent to allow for liquid application. Solar Powder solar panels can be produced at scale and high yield.

Innovative Space Tech. LLC (Gainesville, FL, UF Technology)
Innovative Space Technologies is a solar energy company commercializing an adhesive polymer that can increase the power output of existing photovoltaic cells by up to 30%. The company focuses on developing PV and LED lighting enhancements, and its product portfolio has the potential for commercial, retail, original equipment manufacturer (OEM) and space-based applications.

Evident Energy (Gainesville, FL, UF Technology): *http://evidentenergyltd.com/aboutus.html*
Evident Energy is a software-as-service company with a complete utility-to-customer platform that assists utility companies and their customers in energy conservation. Utilities use the Evident platform to deliver customer-facing applications that reduce energy demand, increase utility conservation program efficiency and strengthen customer relationships.

TransformAir Inc. (Tampa, FL, UF Technology): *http://www.transformair.net/*
Transformair is an energy efficient air cleaner that rapidly, safely, and completely destroys most common indoor air pollutants including bacteria, viruses, mold, asthma triggers and allergens.

Omnii Sense, LLC (Jacksonville, FL, UNF Technology): *http://evankell.wix.com/omniisense*
Omnii Sense LLC is a developer of intelligent wireless sensor networks that gather, record, and report real time data for multiple industries including energy, health, environmental, and security. The Omnii Sense "smart" sensor technology requires no human interaction once activated and no retrofitting to existing infrastructure. The sensors automatically establish a viable communication path, identify nearest neighbors, perform self-healing in the event of disruption, and can be used to detect everything from energy consumption, to microbes and chemical warfare agents.

Mud Power, Inc. (Saint Petersburg, FL – USF Technology)
https://gust.com/c/mud_power_inc - Mud Power has developed modular long-term power solutions that harness energy generated in a natural process by microorganisms found in marine sediments. Customers will be able to significantly increase the length and data resolution of their deployments located near the seafloor.

Trash 2 Cash-Energy LLC (Tampa, FL – USF Technology)
http://www.trash2cashenergy.com/ - Trash 2 Cash converts landfill gas to customer specific liquid fuel. The proprietary gas to liquid process converts naturally produced landfill gas (LFG), composed mainly of methane and carbon dioxide to hydrocarbon fuels specific to the customer needs such as diesel fuel. Trash 2 Cash couples a patent pending Fischer Tropsch (FT) eggshell catalyst to an innovative process design, incorporating a novel tri-reforming reaction to reduce the troublesome impurities found in crude bio-derived gases and produce desired syngas for the FT reaction. This alleviates many problems associated with accumulating municipal solid waste (MSW) in landfills and provides a domestic, sustainable, green fuel.

Sunborne Energy (USF Faculty partnership): *http://sunborneenergy.com/sunborne*
SunBorne Energy is working to make low-cost, utility-scale solar energy a reality in India – a country that has the ideal environment to capture sunlight and generate enough solar energy to meet all its needs. To maximize India's potential, and make utility scale solar energy possible in the near future, SunBorne Energy has brought into its fold internationally acclaimed experts in solar power generation and a host of other technologists and scientists who specialize in this area.

USF Technology transfer to New Energy Technologies Inc.* (Columbia MD, USF Technology)
http://www.newenergytechnologiesinc.com/technology/solarwindow
New Energy Technologies is not a university spin off; however they licensed USF SolarWindow™ technology, which enables see-through windows to generate electricity by 'spraying' their glass surfaces with New Energy's electricity-generating coatings – the subject of eleven patent filings.

Companies Formed But Did Not Survive:

Almos Battery Corporation (Orlando, FL – UCF Technology)
The company is engaged in developing a new battery technology which is safe & low cost for electric power grid applications. The proposed product is a prototype battery which is scalable to megawatts power and megawatts-hr energy. The prototype battery is being built. The battery allows the operation to be on an unattended basis for extended period of time. Integration of battery system into utility transmission and distribution is a mature and well defined process.

Mesdi Systems Inc. (Orlando FL – UCF Technology)
http://megawattventures.com/2012/05/29/mesdi-systems-wins-100000-in-acc-clean-energy-challenge/
Mesdi Systems supplies next-generation spray equipment for manufacturing advanced coatings and chemical powders where high quality and product uniformity are vital. Applications requiring these high precision powders and coatings include lithium-ion batteries, solar cells, LED lighting, semiconductors, pharmaceuticals, and medical implants.

CeramiPower, Inc. (Orlando FL – UCF Technology)
CeramiPower, Inc. was founded to develop ceramic based combustion products and combined heat and power unit (CHP) for both military and civilian applications.

Energy Management Professionals (Lutz, FL – USF Technology)
Energy Management Professionals (EMP) was formed to develop and commercialize new technologies that improve the energy efficiency of existing products and processes. The Company's particular focus was on energy generation utilizing thermodynamics, heat transfer and heat exchange, which are important to the heating, ventilation, air conditioning, and refrigeration ("HVACR") industries and to the current invention. EMP held the rights to two (2) patent-pending applications: ECOGEN Co- Generation System and ReadyPower Portable Power Storage Unit.

P.V. Integrated (Orlando FL – UCF Technology)
P.V. Integrated was formed to develop a novel process for low cost, high throughput manufacturing of CIGS Thin-Film solar cells.

UB-WiSystems, Inc. (Gainesville, FL – UF Technology)
http://megawattventures.com/teams/ubwisystems/
UB-WiSystems, Inc. was founded in May 2012 to provide ultra-low power transceiver solutions for Wi-Fi enabled consumer electronics.

APPENDIX C – FUNDING OPPORTUNITIES SENT TO FESC FACULTY

138 funding opportunities were sent to the faculty during the reporting period of **Oct. 1, 2014 to September 30, 2015.** The details are given in the table below.

#	Title	Call #	Agency	Total Funding	Date Posted
1	Advanced Research In Dry-cooling (ARID)	DE-FOA-0001197	DOE	$30M	10/1/2014
2	Concentrating Solar Power: Advanced Projects Offering Low LCOE Opportunities (CSP: APOLLO)	DE-FOA-0001186	DOE	$25M	10/1/2014
3	FY 2015 Continuation of Solicitation for the Office of Science Financial Assistance Program	DE-FOA-0001204	DOE	$400M	10/1/2014
4	Scanable Nanomanufacturing	NSF 15-507	NSF	$5M	10/1/2014
5	Systems Biology Research to Advance Sustainable Bioenergy Crop Development	DE-FOA-0001207	DOE	$15M	10/1/2014
6	Transportation Energy Resources From Renewable Agriculture (TERRA)	DE-FOA-0001211	DOE	$30M	10/1/2014
7	Request for Information regarding "Assisting Federal Facilities with Energy Conservation Technologies, Fiscal Year 2015" (AFFECT 2015)	DE-FOA-0001203	DOE	Not Specified	10/9/2014
8	Solid-State Lighting Advanced Technology R&D- 2015	DE-FOA-0001171	DOE	$10M	10/14/2014
9	Photovoltaic Module Recycling (RFI)	DE-FOA-0001218	DOE	Not Specified	10/15/2014
10	Generators for Small Electrical and Thermal Systems (GENSETS)	DE-FOA-0001198	DOE	$25M	10/16/2014
11	Landscape Design for Sustainable Bioenergy Systems	DE-FOA-0001179	DOE	$5-14M	10/20/2014
12	Wind Energy – Bat Impact Minimization Technologies and Field Testing Opportunities	DE-FOA-0001181	DOE	$2M	10/22/2014
13	Advancing Solutions to Improve the Energy Efficiency of U.S. Commercial Buildings	DE-FOA-0001168	DOE	$9M	10/23/2014
14	SBIR/STTR 2015 Phase II Release 1	DE-FOA-0001193	DOE	$90M	10/23/2014

15	Sustainable and Holistic Integration of Energy Storage and Solar PV (SHINES)	DE-FOA-0001108	DOE	$15M	10/28/2014
16	Request For Proposals (RFP) Solid and Hazardous Waste Research State University System of Florida	RFP Solid and Hazardous Waste Research	Hinkley Center	Not Specified	11/3/2014
17	Sustainable and Holistic Integration of Energy Storage and Solar PV (SHINES) (NOI)	DE-FOA-0001220	DOE	$15M	11/10/2014
18	Traveler Response Architecture using Novel Signaling for Network Efficiency in Transportation (TRANSNET)	DE-FOA-0001199	DOE	$10M	11/10/2014
19	Building America Industry Partnerships for High Performance Housing Innovations	DE-FOA-0001117	DOE	$4M	11/12/2014
20	Integrated Photonics Institute for Manufacturing Innovation (IP-IMI)	FOA-RQKM-2015-0009	Air Force	$110M	11/13/2014
21	ORAU Faculty Travel Grants Program	-	Oak Ridge Associated Universities	$800	11/15/2014
22	Broad Agency Announcement (BAA) for Powering Agriculture: An Energy Grand Challenge for Development (PAEGC) Second Global Innovation Call	AID-SOL-OAA-00005	USAID	$10-20M	11/18/2014
23	DOE Scholar Program	DOE Scholar Program	DOE	$600/wk stipend	11/18/2014
24	International Affairs Fellowship in Nuclear Security	#NAME?	Council on Foreign Relations' IAF-NS	Stipend of $125K	11/18/2014
25	Stanton Nuclear Security Fellowship	Stanton Nuclear Security Fellowship	Council on Foreign Relations’	Stipends of $110,000 for junior (non-tenured) faculty; $80,000 for postdoctoral; and $50,000 for predoctoral fellows	11/19/2014
26	#BioenergizeME	DOE #BioenergizeMe	DOE	None	12/4/2014
27	Buildings University Innovators And Leaders Development (BUILD) - 2015	DE-FOA-0001167	DOE	$1M	12/4/2014
28	Collegiate Wind Competition	RFC-5-52004	DOE	Not Specified	12/4/2014
29	Hydrogen Student Design Contest	DOE Hydrogen Student Design Contest	DOE/Hydrogen Education Foundation	Not Specified	12/4/2014
30	Race to Zero Student Design Competition	DOE Race to Zero	DOE	Not Specified	12/4/2014

31	Exploratory Research for Extreme-Scale Science	DE-FOA-0001250	DOE	$3M	12/8/2014
32	Gulf Research Program Early-Career Research Fellowships	NAS Gulf Early Career Research Fellowships	National Academies of Science	Undergraduate Stipend: $45K; Graduate Stipend : $55K	12/8/2014
33	Gulf Research Program Science Policy Fellowships	NAS Gulf Science Policy Fellowships	National Academies of Science	Undergraduate Stipend: $45K; Graduate Stipend : $55K	12/8/2014
34	Physics of Reliability: Evaluating Design Insights for Component Technologies in Solar 2 (PREDICTS2)	DE-FOA-0001195	DOE	$9.7M	12/8/2014
35	Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR)	DE-FOA-0001227	DOE	$23.735M	12/8/2014
36	Exploratory Grants – Award Year 2015	NAS Exploratory Grants	National Academies of Science	$2M	12/9/2014
37	Micro-Scale Optimized Solar-Cell Arrays with Integrated Concentration (MOSAIC)	DE-FOA-0001255	DOE	$15M	12/11/2014
38	Micro-Scale Optimized Solar-Cell Arrays with Integrated Concentration (MOSAIC) (SBIR/STTR)	DE-FOA-0001256	DOE	$10M	12/11/2014
39	Naval Platform Power and Energy	ONR-15-SN-0005	DOD	$1.2M	12/11/2014
40	Armament Technology Broad Agency Announcement - Solicitation 1	BAA-RWK-2014-0001	DOD	$4.75M/contract (2 contracts anticipated)	12/16/2014
41	Energy Conservation Applications for US Navy	N00167-15-BAA-01	Dept of the Navy	Not Specified	12/16/2014
42	Mickey Leland Energy Fellowship	DOE Energy Fellowship	DOE	Weekly stipends of $600 for undergraduate students; $750 for Master's students; $850 for Doctoral and Post-Doctoral students	12/16/2014
43	H2 Refuel H-Prize Competition	DOE Refuel H-Prize Competition	DOE	$1M	12/18/2014
44	Summer Undergraduate Research Fellowship	2015-NIST-SURF-02	US DOE/Hydrogen Education Foundation	Not Specified	12/23/2014
45	Advanced Research Projects Agency - Energy (ARPA-E)	DE-FOA-0001261	DOE	$125M	1/7/2015

46	Summer 2015 U.S. Department of Energy Clean Cities University Workforce Development Program (CCWUDP)	DOE CCWUDP	DOE	Stipend: $3.6K - $6K	1/10/2015
47	SunShot National Laboratory Multiyear Partnership (SuNLaMP) Call for Proposals	SuNLaMP0000000	DOE	$112M	1/13/2015
48	AFRI Food, Agriculture, Natural Resources and Human Sciences Education and Literacy Initiative	USDA-NIFA-AFRI-004797	USDA	$16.9M	1/16/2015
49	Energy Audits	RDBCP-REAP-2015	USDA	$2M	1/16/2015
50	Flexible Hybrid Electronics Manufacturing Innovation Institute	BAA-RQKM-2015-0014	Dept of the Air Force	$75M	1/16/2015
51	FY2015 Vehicle Technologies Office Incubator	DE-FOA-0001213	DOE	$14M	1/16/2015
52	LITECAR Challenge	ARPA-E LITECAR Challenge	DOE ARPA-E	up to $60K	1/16/2015
53	Marine and Hydrokinetic Systems Performance Advancement II (SPA II): Component Metric Validation	DE-FOA-0001182	DOE	Area 1: $2.5M; Area 2: $2M; Area 3: $1.5M	1/16/2015
54	Topical Collaborations in Nuclear Theory	DE-FOA-0001269	DOE	$6.5M	1/16/2015
55	State Energy Program 2015 Competitive Awards	DE-FOA-0001222	DOE	$5M	1/20/2015
56	Fiscal Year 2015 Vehicles Technologies Program	DE-FOA-0001201	DOE	$55.8M	1/23/2015
57	Neutron Sciences Call for Proposals	ORNL Nuetron Sciences	Oak Ridge National Laboratory	Not Specified	1/23/2015
58	Support of Advanced Coal Research at United States Colleges and Universities	DE-FOA-0001245	DOE	$3M	1/23/2015
59	Enabling Technologies for Advanced Combustion Systems (ACS)	DE-FOA-0001247	DOE	$12.8M	1/27/2015
60	Lab & Bench-Scale Applications for R&D of Transformational CO2	DE-FOA-0001235	DOE	$43M	1/27/2015
61	Computational Material Sciences	DE-FOA-0001276	DOE	$8M	1/30/2015
62	DOE Office of Science Graduate Student Research Program	DOE SCGSR 2015	DOE	Living Stipend up to $3K	1/30/2015
63	Offshore Storage Resource Assessment	DE-FOA-0001246	DOE	$9M	1/30/2015
64	Resilient Electricity Delivery Infrastructure Initiative	DE-FOA-0001219	DOE	$3.5M	1/30/2015

65	Sunshot Technology to Market (Incubator Round 10, Solarmat Round 2, Sunpath Round 2)	DE-FOA-0001225	DOE	$45M	1/30/2015
66	Transitional Technology Development to Enable Highly Efficient Power Systems with Carbon Management	DE-FOA-0001238	DOE	$38.24M	1/30/2015
67	Amendment 000002 - Building Technologies Office National Laboratory Call & Merit Review FY2016	BTOLMR1600017	DOE	Not Specified	2/4/2015
68	Network Optimized Distributed Energy Systems (NODES)	DE-FOA-0001289	DOE	$30M	2/6/2015
69	Installation Energy Solicitation	DOD Installation Energy	DOD	$3-6M	2/9/2015
70	SEES: Interactions of Food Systems with Water and Energy Systems	NSF 15-040	NSF	Not Specified	2/9/2015
71	Solar Powering America by Recognizing Communities (SPARC)	DE-FOA-0001241	DOE	$13M	2/9/2015
72	Solid Oxide Fuel Cell (SOFC) Innovative Concepts and Core Technology Research Program	DE-FOA-0001229	DOE	$9.5M	2/9/2015
73	BASF Science Competition	BASF Science Competition	BASF	Each finalist team/$5K	2/11/2015
74	EERE Postdoctoral Research Awards	DOE EERE Postdoctoral Research	DOE	$65K annual stipend	2/11/2015
75	Solid Oxide Fuel Cells (SOFC) Prototype System Testing Project	DE-FOA-0001244	DOE	$12M	2/11/2015
76	University Turbine Systems Research	DE-FOA-0001248	DOE	$6.4M	2/11/2015
77	Innovative Development in Energy-Applied Science (IDEAS)	DE-FOA-0001002	DOE	$10M	2/20/2015
78	U.S. Wind Manufacturing: Larger Blades to Access Greater Wind Resources Grant	DE-FOA-0001277	DOE	N/A	2/20/2015
79	FY2015 Support of Advanced Fossil Resource Utilization research by Historically Black Colleges and Universities and Other Minority Institutions (HBCUs/OMIs)	DE-FOA-0001242	DOE	$750K	2/22/2015
80	Biomass Research and Development Initiative	USDA-NIFA-9008-004957	DOE/USDA	$8.7M	2/26/2015
81	Small and Large Scale Pilots for Reducing the Cost of CO2 Capture and Compression	DE-FOA-0001190	DOE	$143.5M	2/26/2015
82	Hydrogen and Fuel Cell Technologies Research, Development, and Demonstrations	DE-FOA-0001224	DOE	$35M	3/4/2015

83	U.S.-China Clean Energy Research Center: Energy and Water	DE-FOA-0001285	DOE	$12.5M	3/9/2015
84	Florida Space Research Program (FSRP)	2015 FSRP	NASA	$250K	3/16/2015
85	Academic Collaboration of Cybersecurity of Energy Delivery Systems Research and Development for the Energy Sector	DE-FOA-0001252	DOE	$2.75M	3/18/2015
86	Special Research Grants Program Potato Breeding Research	USDA-NIFA-SRGP-004996	USDA	$1.242M	3/19/2015
87	Intelligent Monitoring Systems and Advanced Well Integrity and Mitigation	DE-FOA-0001240	DOE	$11M	3/25/2015
88	CleanTech University Prize (Cleantech UP)	DE-FOA-0001271	DOE	$2.5M	3/26/2015
89	Next Generation Electric Machines: Megawatt Class Motors	DE-FOA-0001208	DOE	$20M	3/26/2015
90	In-Water Wave Energy Conversion (WEC) Device Testing Support - Notice of Intent (NOI)	DE-FOA-0000704	DOE	Not Specified	3/27/2015
91	Supplemental and Alternative Crops Competitive Grants Program	USDA-NIFA-OP-004976	USDA	$768K	3/27/2015
92	Technology Development and Assessment for Supercritical Carbon Dioxide (SCO2) Based Power Cycles	DE-FOA-0001239	DOE	$9.4M	3/27/2015
93	Big Data Regional Innovation Hubs (BD Hubs)	NSF 15-562	NSF	$4M - $5M	3/31/2015
94	Research and Education Grant CFP	N/A	USDA (SSARE)	100-250K	4/13/2015
95	Graduate Student Grant CFP	N/A	USDA (SSARE)	11K	4/14/2015
96	Professional Development Program CFP	N/A	USDA (SSARE)	No funding cap, priority to those less than $80K	4/15/2015
97	Sustainable Community Innovation Grant CFP	N/A	USDA (SSARE)	35K/project	4/16/2015
98	AgrAbility: Assistive Technology Program for Farmers with Disabilities	USDA-NIFA-SLBCD-005058	USDA	$4.2M	4/16/2015
99	University Coalition for Fossil Energy Research	DE-FOA-00001267	DOE	$20M	4/17/2015
100	2015 EPA Science to Achieve Results (STAR) Fellowships for Graduate Environmental Study	N/A	EPA	$7.2M	4/17/2015
101	Defense Energy Technology Website	N/A	DOD	Not Specified	4/17/2015

102	Research and Development of Innovative Technologies for Low Impact Hydropower Development	DE-FOA-0001286	DOE	$7M	4/17/2015
103	Theoretical Research in Magnetic Fusion Energy Science	DE-FOA-0001336	DOE	$5M	4/17/2015
104	Technologist-In-Residence Pilot: Laboratory Call for Proposals	SPOTIR-0000018	DOE	$2.3M	4/22/2015
105	2016 INCITE Call for Proposals	N/A	DOE	Award of Time	5/7/2015
106	Dynamic Distributed Resource Management (DDRM)	DE-FOA-0001344	DOE	3.5M	5/15/2015
107	FY 2015 Rapid Innovation Fund	HQ0034-15-BAA-RIF-0001	DOD	3M	5/18/2015
108	SOLAR TRAINING AND EDUCATION FOR PROFESSIONALS (STEP)	DE-FOA-0001329	DOE	12M	5/31/2015
109	CONCENTRATING SOLAR POWER: CONCENTRATING OPTICS FOR LOWER LEVELIZED ENERGY COSTS: (COLLECTS)	DE-FOA-0001268	DOE	15M	5/31/2015
111	Storage Systems and Input/Output for Extreme Scale Science	DE-FOA-0001338	DOE	4M	5/31/2015
110	SDN-Enabled Terabits Optical Networks for Extreme-Scale Science	DE-FOA-0001295	DOE	5M	6/1/2015
112	Regional Conservation Partnership Program	USDA-NRCS-NHQ-RCPP-16-01	USDA	225M	6/2/2015
113	The US-Israel Binational Agricultural Research and Development Fund (BARD)	N/A	Not Specified	32M	6/8/2015
114	Research on Innovative Approaches to Fusion Energy Sciences	DE-FOA-0001348	DOE	6.2M	6/8/2015
115	Nuclear Science and Engineering Nonproliferation Research Consortium	DE-FOA-0001300	DOE	25M	6/8/2015
116	Technologies Directed at Capturing Carbon Dioxide from Low Concentration Sources to Support the Coal Industry	DE-FOA-0001342	DOE	3M	6/8/2015
117	Industry/University Cooperative Research Centers Program	N/A	NSF	12M	6/18/2015
118	GENERATING REALISTIC INFORMATION FOR DEVELOPMENT OF DISTRIBUTION AND TRANSMISSION ALGORITHMS (GRID DATA)	ARPA -E: DE-FOA-0001357	DOE	7M	6/19/2015

146	Request for Information (RFI): High Impact Commercial Building Technology Deployment	DE-FOA-0001352	DOE	N/A	7/2/2014
119	Opportunities to Develop High Performance, Economically Viable, and Environmentally Benign Technologies to Recover Rare Earth Elements (REEs) from Domestic Coal and Coal Byproducts	DE-FOA-0001202	DOE	20M	7/8/2015
120	National Spherical Torus Experiment – Upgrade: Diagnostic Measurements of Spherical Torus Plasmas	DE-FOA-0001359	DOE	4.5M	7/8/2015
121	ABB Research Award in Honor of Hubertus von Grünberg	N/A	ABB Technology Ltd	$300,000	7/14/2015
122	FY 2016 Research Opportunities in High Energy Physics	DE-FOA-0001358	DOE	40M	7/21/2015
123	Intermediate Neutrino Research Program	DE-FOA-0001381	DOE	10M	7/21/2015
124	GENerators for Small Electrical and Thermal Systems (GENSETS) (SBIR/STTR)	ARPA -E: DE-FOA-0001380	DOE	7M	7/21/2015
125	DOE Traineeship in Power Engineering (Leveraging Wide Bandgap Power Electronics)	DE-FOA-0001378	DOE	5M	7/21/2015
145	Collaborative Fusion Energy Research in the DIII-D National Program	DE-FOA-0001375	DOE	3M	7/28/2015
143	Early Career Research Program	DE-FOA-0001386	DOE	18M	8/8/2015
144	DOE Traineeship in Robotics	DE-FOA-0001374	DOE	2M	8/8/2015
142	Advanced Reactor Industry Competition for Concept Development	DE-FOA-0001313	DOE	80M	8/8/2015
139	Scientific Infrastructure Support for Consolidated Innovative Nuclear Research	DE-FOA-0001282	DOE	Up to 3M for different projects	8/15/2015
140	FY2016 Consolidated Innovative Nuclear Research Funding Opportunity Announcement	DE-FOA-0001281	DOE	56.2M	8/15/2015
141	Berkeley Cleantech University Prize (CUP)	N/A	DOE/BECI/BERC	100K	8/21/2015
126	NSF/DOE Partnership in Basic Plasma Science and Engineering	NSF 15-601	NSF	3M	8/25/2015
127	Energy, Power, Control and Networks (EPCN)	NSF PD 13-7607	NSF	$8000 per REU student	8/25/2015
128	FY 2016 Phase I Release 1	DE-FOA-0001366	DOE	200M	8/25/2015

129	Solar Decathlon Program Administrator	DE-FOA-0001371	DOE	3M - 4M	8/28/2015
130	Bioenergy Technologies Incubator 2	DE-FOA-0001320	DOE	10M	8/28/2015
131	FEW Workshops	N/A	NSF	N/A	9/4/2015
132	U.S.-Israel BSF International Opportunity	NSF - PD 15-7644	NSF	N/A	9/9/2015
133	Nuclear Power Cell	CRNBAA16-002	DOD	80K	9/10/2015
134	Time Varying Nuclear Decay	CRNBAA16-001	DOD	80K	9/10/2015
135	High-Impact Nanoscience Research	N/A	Oak Ridge National Laboratory	N/A	9/10/2015
136	Medium and Heavy Duty Vehicle Powertrain Electrification and Dual Fuel Fleet Demonstration	DE-FOA-0001349	DOE	10M	9/14/2015
137	Photovoltaics Research and Development (PVRD)	DE-FOA-0001387	DOE	20M	9/22/2015
138	Sunshot Technology to Market (Incubator Round 11, Solarmat Round 4)	DE-FOA-0001400	DOE	30M	9/22/2015

APPENDIX D – PROJECT PROGRESS/FINAL REPORTS

NSF Solar Energy Pathways

PI: Mark Jamison, Public Utility Research Center, University of Florida

Partners: Richard Boampong, Deniz Kazanci, Amanda Phalin, Michelle Phillips
Project Time Period: 2013-2018

Summary
Research regarding economic issues and incentives involved with Solar PV.

Goals and Objectives

The research is addressing three key questions.

1. What is being done to implement thin film solar technologies in developing countries, what problems are being encountered, and how are the problems being overcome?
2. What are the successful applications of thin film solar technologies in developing countries?
3. What are the key product features, economic characteristics, supply chain needs, and support systems for successful implementation of earth abundant kesterite-based, thin film PV materials?

Project Activities, Results and Accomplishments (This is the main body of report and may use other headings such as Research Description, Results, etc. – author's choice. Items that should be included are accomplishments, benefits to the state and how funds were leveraged.

Post-doc Amanda Phalin and graduate student Richard Boampong identified the target countries, namely India, Kenya, and South Africa, but gathered information on other countries as well. The specific research questions include:

- What do thin film solar programs look like in these countries? What is the government implementing? What is the private sector producing and selling?
- What problems have adopters in these countries (e.g., customers, businesses, governments, and utilities) had/overcome in implementing thin film solar technologies/programs (e.g., were there certain products that were not adaptable and why?)?
- What were the keys for the successful products (e.g., price points and price design, physical characteristics of products, distribution channels)?
- How successful are/were thin film products in competing against existing PV, retail electricity, consumer fuels (e.g., kerosene), and the choice of no electricity?
- What is the thin-film technology used for (e.g., electricity generation vs. solar heating for cooking)?
- Do the thin-film products tend to be on- or off-grid?
- What support systems have to be in place (e.g., maintenance and repair, consumer education, and financing)?
- What type of government restrictions or support matter? Rich Text Area

Over 100 papers, reports, and articles from academic journals, researchers, NGOs, governments, and inter-governmental organizations have been identified and reviewed. The markets for renewable energy in our target countries look similar and can be divided into two main broad categories:

On-grid renewable energy projects and Off-grid projects. On-grid renewable energy projects allow investors to supply energy to the already existing grid to supplement the under-capacity installed supply of energy and to improve on the unreliability of energy supply. It is normally implemented in urban and peri-urban areas where there is a power infrastructure in place already. Off grid system comprises all the other renewable energy projects using stand-alone generators, residential home system for homes or small renewable energy units such as small solar lanterns and cooking stoves. While in some countries these different categories of off-grid systems can further be categorized into three main segments, there are no clear distinction between these categories in other countries and the same government regulation is used for all off-grid projects. For the purpose of this project, we categorize the different off-grid renewable energy systems as separate and distinguishable so that the market for renewable energy in our target countries or in developing countries as a whole can be grouped into the following five broad segments:

1. On-grid renewable energy projects: Products for utility-scale and customer-scale applications where the power generated is sold to others, including to the utility.
2. Small Off-grid Systems: Products primarily for residential solar home systems, especially in rural areas, and for small-scale commercial photovoltaic (PV) applications, such as kiosk lighting and mobile phone charging.
3. Large Off-grid Systems: Products providing power for larger institutions, such as schools, health centers, and missions in rural areas and for water pumping. These products are mainly solar PV.
4. Solar Powered Base Stations: Products primarily for powering mobile phone and broadcasting base stations, for and tourism establishments.
5. Small Units: Products that power specific small applications, such as solar lanterns and solar cooking stoves.

Detailed country case studies are being developed for each category.
Junior Economist Michelle Phillips is looking at the regulatory environment in Brazil, Kenya, Island Nations, and China and institutional features that are relevant for PV adoption. Benefits to the state include having a better idea of what other cities and countries are doing to incentivize solar PV use, and a better understanding of the complexities of PV adoption/incentives.
In her recent presentations she looked at:
- Off-grid challenges, financing, products and business models.

- Potential customers for solar PV in Brazil and in Small Island nations

- How to increase solar PV penetration.

- Utility scale projects

- Barriers to adoption.

Michelle Phillips is in the process of writing up a policy paper focusing on Kenya, which will include her research on Kenya's regulatory environment and PPAs plus research done by Mark Jamison, Richard Boampong, and Amanda Phalin on Kenya's Feed in Tariffs.

Simulation and Measurement of Biomass Suspension Rheology

PI: Jennifer Sinclair Curtis, Chemical Engineering, University of Florida
Project Period: 8/2014-7/2016

Summary: Biomass is a promising source of renewable energy. Although this form of energy production holds much potential to reduce energy dependence on petroleum-based fuel consumption, ***one key challenge in the large-scale commercialization of these systems is the physical handling of biomass suspensions.*** These suspensions span a wide spectrum of solids concentrations and particle size during the various biomass processing steps. ***Fibrous suspensions are also being used increasingly in petroleum exploration applications.*** Fibers have been used since at least the 1960's in petroleum exploration as an additive to well cement to increase its strength. Fibers increasingly are added to drilling muds to alter the rheology in an effort to improve performance of the fluid for the purpose of carrying rock cuttings from the drill bit to the surface. More recently, industry has been using fibrous suspensions to solve critical problems with regard to hydrofracturing.

In this project, a combined program of simulation and experimentation is utilized to investigate the dynamics and rheology of fibrous suspensions of biomass. In order to reliably design and optimally operate biomass processes, the rheological behavior of these complex fluids over a range of solids concentrations and particle size must be understood. On the simulation side, the discrete element method (DEM), capable of calculating stresses and effective viscosity of biomass over a wide span of moisture content (using a liquid bridging model) and particle sizes, is developed. The goal is to study the rheology of well-characterized fibrous suspensions such as fishing wire and then move onto actual biomass (wheat straw and corn stover). These materials will be fully evaluated via experimentation (angle of repose and shear cell testing) and compared with the simulation results. Successful completion of the proposed work will provide insights into the rheological behavior of fiber-filled suspensions that will aid the design and optimal operation of processes in renewable energy.

Goals and Objectives: The goal/objective of this project is to predict the flow behavior of biomass over a range of liquid content and particle aspect ratios.

Project Activities, Results and Accomplishments: Shear flows of dry, flexible fibers were numerically modeled using the Discrete Element Method (DEM) and the effects of fiber properties on the flow behavior and solid-phase stresses were explored. We have verified our DEM model by a comprehensive examination of static and dynamic behavior of particle bending, twisting, and stretching. In Figure 1, this flexible particle DEM model is illustrated via a collinear collision between two flexible particles that have their major axes perpendicular to each other. In the DEM simulations, a fiber is formed by connecting a number of spheres in a straight line using deformable and elastic bonds. The forces and moments induced by the bond deformation resist the relative normal, tangential, bending, and torsional movements between two bonded spheres. The bond or deforming stiffness determines the flexibility of the fibers and the bond damping accounts for the energy dissipation in the fibers' vibration. The simulation results show that elastically-bonded fibers have smaller effective coefficients of restitution than rigidly connected fibers. Thus, smaller solid-phase stresses are obtained for flexible fibers, particularly with bond damping, compared to rigid fibers. Frictionless fibers tend to align in the flow direction with minimal deformation as the solid volume fraction increases. However, jamming, with a corresponding sharp stress increase, large fiber deformation, and a dense contact force network, occurs for fibers with friction at high solid volume fractions. It is also found that jamming is more prevalent in dense flows with larger fiber friction coefficient, rougher surface, larger stiffness, and larger aspect ratio.

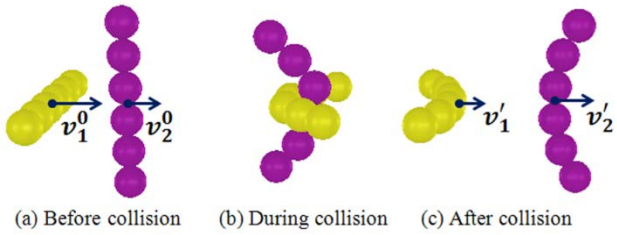


Figure 1: Snapshots of collinear collision between two flexible fibers arranged with two major axes perpendicular to each other.

We have also considered wet, flexible fibers and introduced a liquid-bridge force model for the contacts between constituent spheres. The liquid cohesive force is a function of the surface tension, contact angle, and particle radius. One example validation of the wet, flexible fiber model is an angle of repose test as shown in Figure 2 below. For fishing wire with 4% wire by volume, experiments predict an angle of repose of 20 degrees and simulations predict an angle of repose of 19 degrees.

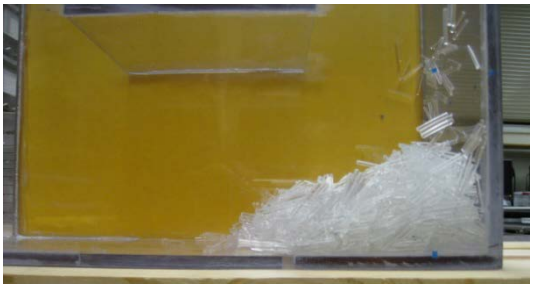
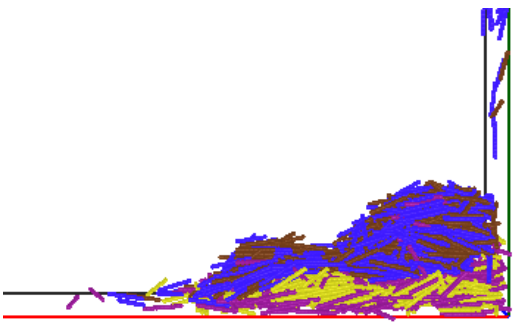
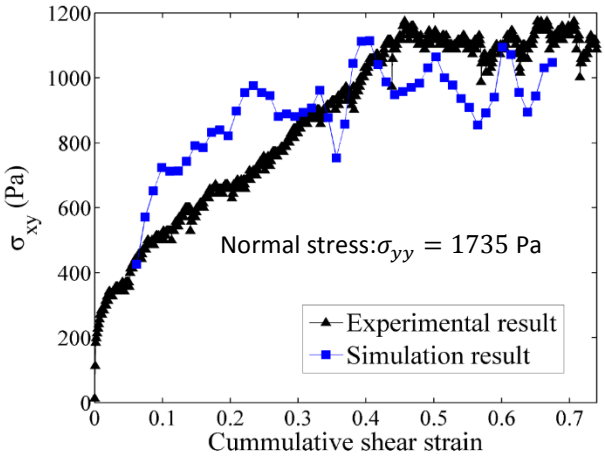
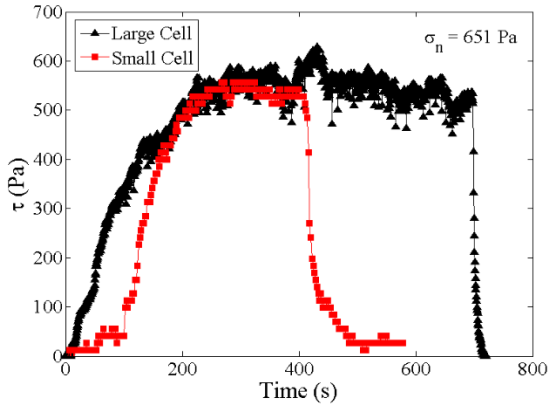


Figure 2. Experimental and simulated pile formation for wet (4% water by volume) fishing wire (2mm x 18mm)

DEM simulations also have been conducted to predict the effective stress of dry fibers and have been compared with experimental measurements in Schulze shear cell tests. We have performed these complementary experiments for the dry fishing wire in two sizes of a Schulze shear flow tester. The fibers have an aspect ratio 9, so we needed to verify that our experimental results were not system-size dependent. Figures 3a and 3b below indicates that for the fishing wire fibers the experimental results are not system-size dependent. Figure 3c shows that the simulated stress compares very favorably with the measured stress.







		Small Schultz Shear Cell	Large Schultz Shear Cell
Ring Diameters	Inner	10 cm	21.8 cm
	Outer	20 cm	36 cm
Depth of Inner Cell		4 cm	7.4 cm

Figure 3 (a), (b), (c)

Concluding Remarks: In the next reporting period, we will validate our DEM model with shear cell experimentation for wet fibers and angle of repose testing on biomass material (wheat straw).

Publications:

Y. Guo, C. Wassgren, B. Hancock, W. Ketterhagen, and J. Curtis,, "Computational study of granular shear flows of dry, flexible fibers using the discrete element method", Revisions submitted to *Journal of Fluid Mechanics*, 2015.

Y. Guo and J. Curtis, "Discrete Element Method Simulations for Complex Granular Flows" (Invited), *Annual Review of Fluid Mechanics*, **47**, 21-46 (2015)

Presentations: Plenary Talk, "The Role of Shape in Particle Transport Processes", Conveying and Handling of Particulate Solids (CHOPS 2015), Tel Aviv, Israel, May 5, 2015

Southeast National Marine Renewable Energy Center (SNMREC)

Florida Atlantic University

PI: Susan H. Skemp, **Co-PIs:** Howard P. Hanson, Taghi Khoshgoftaar, Pierre-Phillippe Beaujean, Len Berry, Megan Davis, Jeanette Wyneken, Manhar Dhanak, Eric Chassignet, John Reed, Charles Messing, James VanZwieten, Karl vonEllenrieder, Julie Lambert, Hassan Mahfuz, Stewart Glegg, George Frisk, Bassem Alhalabi, Hari Kalva, Steve Kajura, Madasamy Arockiasamy, Francisco Presuel-Moreno, Isaac Elishakoff, Fraser Dahlgleish, Anni Dahlgleish, Bing Ouyang, Jose Principe

Note: Student listing is appended

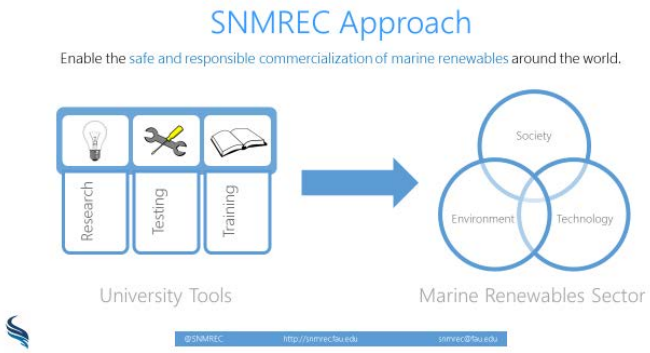
Budget: $8,750,000; Funding **Leveraged:** U.S. Department of Energy, National Science Foundation and Industry - $6,281M

Description: The Southeast National Marine Renewable Energy Center (SNMREC) at Florida Atlantic University (FAU) was established by an award from the U.S. Department of Energy (DOE) in 2010 as an extension of FAU's Center for Ocean Energy Technology, which was originally founded in 2007 by the 2006 Florida State University System Center of Excellence Program. The SNMREC is investigating harnessing power from ocean currents, such as the Gulf Stream, as well as ocean thermal energy conversion to generate base-load electricity. This baseload, sustainable resource will make a unique contribution to a broadly diversified portfolio of renewable energy for the nation's future. Key drivers for investigation are determined by the regulatory process at State and Federal levels and by market and technology gaps needed to commercialize MRE.

Universities: Florida Atlantic University, collaborating with the University of Central Florida, Florida State University, University of South Florida, Embry-Riddle Aeronautical University, University of Miami, Oregon State University, University of Washington, Pennsylvania State University, University of New Hampshire, University of Hawaii, University of Edinburgh, Heriot-Watt University, Nova Southeastern University, Virginia Polytechnic Institute and State University, and Florida Institute of Technology, North Carolina Coastal Studies Institute, Clemson University, Georgia Institute of Technology, University of the Azores, and Stellenbosch University.

External Collaborators: Numerous industry partners, state and federal government agencies, FFRDCs such as the National Renewable Energy Laboratory, Oak Ridge National Laboratory, Woods Hole Oceanographic Institution, U.S. Department of Energy (Office of Energy Efficiency and Renewable Energy), U.S. Department of Interior (Bureau of Ocean Energy Management, Regulation, and Enforcement), U.S. Department of Commerce (National Oceanic and Atmospheric Administration), the Florida Fish and Wildlife Conservation Commission, and Florida Departments of Agriculture and Consumer Services, and Environmental Protection.

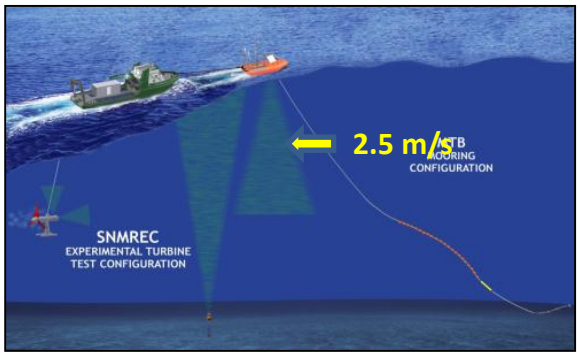
Summary:



The Southeast National Marine Renewable Energy Center (SNMREC) at Florida Atlantic University (FAU) was designated as such through an award from the U.S. Department of Energy (DOE) in 2010 as an extension of FAU's Center for Ocean Energy Technology, which was originally founded in 2007 by the 2006 Florida State University System Center of Excellence Program. The SNMREC is investigating harnessing power from ocean currents, such as the Gulf Stream, as well as ocean thermal energy conversion to generate base-load electricity. This baseload, sustainable resource will make a unique contribution to a broadly diversified portfolio of renewable energy for the nation's future. Key drivers for investigation are determined by the regulatory process at State and Federal levels and by market and technology gaps needed to commercialize MRE. The SNMREC's role is to bridge the gap between concept and commercial deployment of ocean energy technologies by providing at-sea testing facilities and technology development for both ocean current and thermal energy systems. Research areas span environmental, resource, economic, educational, and technology topics.

Goals and Objectives:

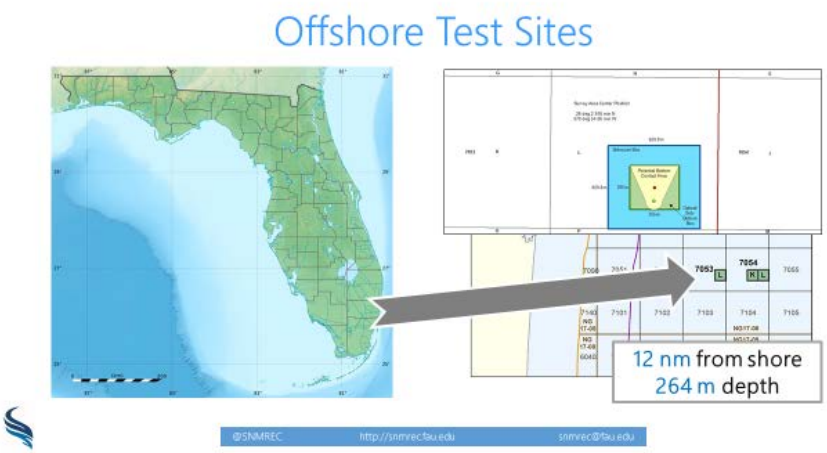
The Southeast National Marine Renewable Energy Center is developing a small-scale open-ocean energy laboratory and test capability to advance research on marine and hydrokinetic (MHK) ocean current energy and thermal potential energy. The SNMREC is moving forward with strategically selected research, developing and testing key technology, infrastructure and systems as well as standards criteria to meet this need. The collective objective of this project is to provide industry with tools and solutions in areas that have been identified as initial market accelerators.



Small-scale open-ocean test berth

These areas are being addressed according to the U.S. Department of Energy's (DOE) Technology Readiness Level (TRL) scale, specifically, levels 3 (Analytical or experimental critical function proof of concept) through 5 (Laboratory scale validation in relevant environment). The expected outcomes include investigations and solutions for technical gaps in intelligent sensor systems, reliability and prognostics systems, rotor instrumentation and modeling, and composite materials applications for energy extraction devices and components. The first step towards achieving this goal is to install a non-grid connected TRL5/6 offshore test berth and demonstrate its readiness with an accompanying small-scale research and development ocean current turbine unit.

Project Activities, Results and Accomplishments:



The successful implementation of an in-water testing infrastructure for MHK off the coastline of Florida will be the first and only such capability globally. Already, companies from both the U.S. and internationally have expressed a desire to work with the SNMREC in defining not only their test requirements based on their design, but also are exploring both short term occupancy in Florida and potentially longer term manufacturing and grid connection in developing arrays for commercial enterprises.

An MHK lease application on the outer continental shelf (OCS) was submitted to the U.S. Department of Interior, Bureau of Ocean Energy Management (BOEM). This is the first national application which will form the model for future lease applications. BOEM released the Final Environmental Assessment (EA) with a Finding of No Significant Impact (FONSI) on 12 August 2013. The EA and FONSI can be found on the Department of Interior's website at http://www.boem.gov/Florida-Revised-EA-FONSI-August2013/. Effective 1 June 2014, Florida Atlantic University was granted a 5-year Interim Policy (IP) Lease by the U.S. Department of Interior's Bureau of Ocean Energy Management (BOEM). This lease is the first lease in the U.S. for Marine Hydrokinetic (MHK) Energy activities on the Outer Continental Shelf (OCS), laying the groundwork for industry and other institutions seeking leases in the future. The lease area, that comprises approximately 1,068 acres, lies within Official Protraction Diagram Bahamas NG17 06, covers Block 7053, Aliquot L, and Block 7054, Aliquots K and L (See Figure inserted above). The initial annual lease payment of $3,204 was provided on 7 July 2014.

Under the BOEM lease, an offshore scaled device test berth (approximately 12 nm offshore of Ft. Lauderdale, FL) will be installed to accommodate up to 100kW max instantaneous power production and/or 7m rotor diameter turbine testing. This initial group of industrial devices will provide insight into individual device extraction methods, dynamics, and basic system operability. This project will address the immediate needs of the still immature ocean current energy conversion industry while building a foundation for a future large-scale and grid-connected offshore testing capacity.

Stipulations of the BOEM IP Lease address (I) Payments and (II) Environmental which falls into the following categories: 1) General Environmental, 2) Protection of Archaeological Resources, 3) Protection of Avian and Bat Resources, 4) Protection of Benthic Resources, and 5) Protected Marine Mammal, Sea Turtle and Fish Species. To address categories 2 – 5, Archeological Identification and Benthic Habitat Surveys will be conducted. It was determined that the survey results were required to be integrated into the Project Plan. Per the BOEM Lease, a Survey Plan was submitted to BOEM, and a meeting was held in October with their Subject Matter Experts (SME), at which time BOEM provided their concurrence with the Plan. The survey(s) will commence in mid-May. to identify deep water coral distribution and determine appropriate anchor areas. In addition, the lease stipulates a Project Plan (PP) rather than a Construction Operations Plan (COP) is required. The initial draft has been outlined to describe project objectives and proposed activities based on input from the Department of the Interior. However, further work for this document is on hold pending results from surveys yet to be conducted. The survey(s) are expected to commence in May 2015.

A centralized, standardized testing capability will be provided for testing current energy conversion prototypes; initially, scaled versions and eventually full-scale devices. In addition, critical environmental measurements will be obtained on a continuous basis from the observational platform and submerged instrumentation. Companies from both the U.S. and internationally are working with the SNMREC in defining test requirements based on their design, as well as both short term occupancy in Florida and potentially longer term manufacturing and grid connection options in developing arrays for commercial enterprises.

Finally, as commercial prototypes and subsystems are brought to SNMREC for testing, all aspects of experiment set up, instrument calibration, data handling, and organizational checks/balances are expected to comply with international quality standards (ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories*). The SNMREC is preparing its processes and organization to fully comply with this standard and achieve accreditation. The selected approach is recommended by Agilent Technologies (Huber, 2009) and involves the following steps towards accreditation:

1. Investigation Phase (where an organization defines its scope, gaps, tasks required to achieve accreditation, and estimated costs/ROI)
2. Management Decision
3. Implementation Phase (where an accreditation body is selected, documentation developed, training performed, internal audits and corrections performed, and pre-assessment conducted)
4. Accreditation Audit

The SNMREC's research ocean current turbine (OCT) was tested at sea to evaluate its design stability and tow characteristics. This 3-meter rotor diameter, 20kW generically designed experimental research turbine (Figure 3) will provide a non-proprietary platform for component development at small scales. The SNMREC is also engaged in sensor and instrument acquisition, deployment, and analysis to more fully characterize offshore energy resources, and the benthic and pelagic environment.

Figure 3: During Mobilization at HBOI **At Sea After Successful Deployment**

One of the biggest unknowns in the operation of ocean current turbine (OCT) systems concerns the behavior of the generator sub-system as it experiences both variable loads and the torque differentials associated with changing currents acting on the rotor. In order to provide a capability to test generators and/or associated instrumentation under realistic conditions, the SNMREC has developed a computer-controlled dynamometer system, located at the FAU SeaTech facility in Dania Beach. This basic capability has been further enhanced with simulated oceanographic conditions to emulate rotor behavior on the test stand as it would occur in an actual ocean current. The 20 kW dynamometer has been fitted with the SNMREC's experimental research turbine power quality and health management systems, and has continued generating data for Prognostics and Health Monitoring (PHM) research. Preliminary work has been completed to emulate rotor behavior in wave conditions and from collected offshore measurements. A laboratory capability feasibility study for ocean current turbine testing was completed, and the results are available in an M.S. Thesis format.

Before developers arrive to test their turbines at the SNMREC's small scale offshore test facility, they will require specialized information about the environment in which they will be

deploying their products to ensure their turbines will survive test berth conditions and so that *a*

priori knowledge of the conditions can be incorporated into test design. During testing, in order

to determine the performance of turbines, it is necessary to correlate power production with incoming flow characteristics.

Two new ADCP buoys were designed and fabricated to provide additional spatial data collection capabilities at the proposed test site deployment location (Block 7053). The next deployment is planned for June 2015, and will employ up to six (6) buoys not only within the lease area but further to the north to evaluate the potential variation of flow along the coast of Florida. The buoys will be deployed at various water depths to evaluate current magnitude and direction variation, as well as vorticity and other flow characteristics to

Figure 4 - New ADCP buoys in fabrication.

inform future MHK developers of the more dynamic aspects of the Florida Current. The deployment duration will be between 9 and 12 months, and will include the 2015 hurricane season.

In addition to understanding large- scale flow phenomena, smaller variations (down to the order of turbine rotor blade cord lengths) are important to characterize and model. Understanding turbulence is necessary for commercial ocean current turbine technologists to properly account for design conditions of systems, to provide valuable data for numerical models, and to provide a complete characterization of flow conditions that equipment experiences when deployed at the SNMREC's test site. A towfish was designed, constructed, and tested for SNMREC's motion-compensated ADV system to prepare for offshore turbulence measurements. This tow tests that will focus on refining deployment/retrieval techniques and selecting proper tow points for various flow speeds. Upon successful completion of this final field test, monthly measurements will begin (planned for May 2015 start).This research will involve measurement of turbulence with ADCPs and Acoustic Doppler Velocimeters (ADVs), both at the SNMREC's test berth site and in the primary flow of the Gulf Stream, with a small vessel combined with stand-alone moored approaches. These methodologies and are consistent with a successful measurement program for tidal turbulence characterization by the Northwest National Marine Renewable Energy Center – University of Washington. Data collected will also be critical to advance a joint task to validate and tune numerical turbulence models for design and evaluation of in-stream MHK turbines under an existing CRADA with NREL.

The SNMREC, with FAU's Harbor Branch Oceanographic Institute (HBOI) has established an internship program for up to 4 United States Coast Guard Cadets, during their summer rotation. Cadets have submitted applications for the 2015 program, which are under review. This program will enhance cooperation between the U.S. Coast Guard and the SNMREC while educating future officers about projects which will be installed in coastal areas.

SNMREC staff continue to work with professors and students at FAU's School of Communications and Multimedia Studies' to create an interactive educational display game. A kiosk is being designed for the Ocean Discovery Center at FAU's Harbor Branch Oceanographic Institute. The kiosk will create a hands-on experience which educates the public about future ocean energy projects. The kiosks will increase knowledge of real, cutting-edge research in renewable energy from the ocean as well as, incorporating valuable Science Technology Engineering & Math (STEM) content to inform the public.

The Center developed a curriculum for upper-division high-school students to introduce the topic within secondary education. An additional topic on policy and social interaction with renewable energy, with an emphasis on ocean energy, will be added this summer.

Over fifty upper-division graduates and Principle Investigators have been engaged in research in marine renewable energy (MRE) to date. Approximately a dozen of these students have secured positions in energy-related companies. One of the PhD students was selected as a Knauss Fellow after graduation and is currently serving in the U.S. Department of Energy's Energy Efficiency and Renewable Energy focus in the Wind and Water Power Program. Partnerships between the SNMREC and the marine industry continue to expand.

More than 45 Non-Disclosure Agreements (NDA) have been signed with companies across the global marine industry. Language within the NDAs does not allow for the release of information of the details of the collaborations at this time. Industry sponsored funding is at a level of $155,000.

To date, with the State of Florida funding, the SNMREC has successfully leveraged $6,281M of U.S. Department of Energy and National Science Foundation funds. Four additional proposals are in process awaiting review during this period.

Unifying Home Asset & Operational Ratings: Adaptive Management via Open Data & Participation

FESC Final Report

PROJECT TITLE: Unifying Home Asset and Operational Ratings: Adaptive Management Via Open Data and Participation

PI: Mark Hostetler (Professor, UF Department of Wildlife Ecology & Conservation)

CO-PI: Hal S. Knowles, III (Change Agent, UF Program for Resource Efficient Communities)

SUPPORTED STUDENT(S): Hal S. Knowles, III (Ph.D. Candidate, UF School of Natural Resources & Environment)

INSTITUTION: University of Florida, Institute of Food and Agricultural Sciences, Program for Resource Efficient Communities

PARTNERS: Department of Physics and Department of Psychology, Queens College City University of New York; Florida Solar Energy Center, University of Central Florida

PROJECT TIME PERIOD: Original Project = 01/01/2011 to 12/31/2012 at $24,000; Supplemental Project = 04/01/2013 to 09/30/2014 at $32,000

DATE REPORTED: October 25, 2015

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2. Executive Summary

2.1. Introduction

Since the 1970s, the major methods of home energy analysis have utilized linear-based engineering models of known building asset variables. While these asset models provide useful feedback for the residential energy efficiency industry, their inputs and outputs are constrained by our limited knowledge of these variables and the associated flaws that may arise in our assumptions about their interaction. These constraints have shed light on the important role of occupant behavior on home energy consumption patterns. In response, an entirely new conservation behavior industry has grown around these knowledge gaps. Early attempts to integrate building asset and occupancy analyses suggest improved insights, as well as, new limitations to these operational models.

Are there ways for the home performance sector to accept and work with the inherent uncertainty in the interaction of these diverse and ever-changing building system and human behavioral variables? We believe there are and that the keys to these different, though complementary, ways of understanding may reside in the chaotic order of nonlinear dynamics and their application to the new data streams available through advanced metering infrastructure (AMI). This FESC funded research evaluated two complementary residential building science issues: (1) the usability of an interactive online consumer feedback tool that visually maps monthly residential energy and water consumption trends; and (2) the "complexity" of residential energy consumption patterns through the variability of their short interval electric meter readings over various time scales.

2.2. Objectives

The first objective of the Qualitative Focus Group Research was to test the usability and efficacy of a website (http://gainesville-green) as recorded by users at individual computer terminals. The second objective of the Qualitative Research was to conduct semi-structured focus group interviews with key stakeholders to better understand the role of residential building operational feedback as a tool for conservation behavior changes.

The first objective of the Quantitative Time Series Analysis Phase One was to evaluate the statistical nature of short interval residential smart meter time series data. The second objective of Phase One was to compare the correlations between home size, vintage, and energy use with the new metrics of fractal complexity.

The first objective of the Quantitative Time Series Analysis Phase Two was to evaluate the characteristics and fluctuations of the sub metered energy use time series complexity for further insights into household dynamics across key system variables. The second objective of Phase Two was to correlate the complexities of ambient outdoor weather patterns to home energy use patterns.

2.3. Methods

For the Qualitative Focus Group Research, we developed website usability testing exercises and semi-structured survey questions on key asset and operational rating criteria and their interactions for seven separate focus group sessions conducted in February and March, 2011. These sessions explored household utility service information needs and the usability of a home energy and water reporting website (http://gainesville-green.com/) for customers within the Gainesville Regional Utilities service territory.

Our mixed-mode approach combined individual human-computer interface (HCI) usability testing ranging from 30-53 minutes, immediately followed by semi-structured focus group interviews ranging from 54 to 78 minutes. The interview sessions were based on the methods and principals espoused in Richard Krueger's six characteristics of focus groups. Participants were recruited using a combination of non-probabilistic convenience sampling and snowball sampling of key informants within our six identified stakeholder groups: (1) homeowners involved in local environmental initiatives; (2) homebuilders who participate in programs like Energy Star and/or Building America; (3) certified home energy raters; (4) real estate agents and brokers involved in local green building sales efforts; (5) local government officials and staff working on sustainability programs; and (6) financial industry stakeholders with knowledge about energy efficient mortgages and lending processes.

For the Quantitative Time Series Analyses, we utilized two data sets: (1) 15-minute interval electric readings for approximately 350 homes and apartments in a random sample the JEA service territory of Jacksonville, Florida; and (2) hourly interval electric readings for 60 Florida homes in the Phased Deep Retrofits (PDR) program of the Building America – Partnership for Improved Residential Construction.

First, normality testing was performed on the time series. Second, multifractal detrended fluctuation analysis (MFDFA) was performed on the original increments, shuffled surrogates, and phase randomized surrogates of these time series. Third, MFDFA was performed on the original and surrogate increments of various 15-minute interval weather time series and the disaggregated electric sub-meters of major home systems in the PDR. Fourth, cluster analysis was used to segment and compare the multifractality of the homes and the weather.

2.4. Results

Based on the focus group interviews, having a meaningful home energy use point of comparison is essential. In fact, it may be the most essential criteria of home energy feedback. Every focus group stated that "apples to apples" comparisons are necessary. All stakeholder groups expressed concern that "other" people may be misled by the feedback and draw invalid conclusions. Yet our research team found this interesting because of the implication that "others" would clearly confuse or misunderstand something that virtually all individual stakeholders recognized – that human behavior within buildings can have a profound and confounding effect on utility consumption patterns. Specifically, these qualitative insights suggest that even when adding operational data to building asset data, the reductionist approach to evaluating home energy performance by controlling for known variables may continue to offer an incomplete picture of the complexities of performance trends and the influence of unknown and/or misunderstood variables.

Home energy use is non-normal, non-stationary, leptokurtic, and displays positive (right) skewness. Furthermore, home energy use is fractal with long-range temporal correlations and cluster analysis suggests this fractal complexity is more descriptive of system dynamics than the conventional wisdom key variables of kWh (mean, variance, and sum), home size (square feet), and home vintage (year built).

MFDFA spectra suggest that behaviorally influenced variables may correlate with higher complexity, though further analysis is necessary for a more generalizable confirmation. Sub-daily vs. supra-daily MFDFA singularity spectra suggest both weather and home energy consumption patterns may be driven by different dynamics within days versus across days. Overall, the shape and magnitude of the MFDFA singularity spectra offer a proxy for the complexity of the house as a social-technological system with a mix of known and unknown variables.

2.5. Conclusions

Measuring complexity may provide new ways to differentially "diagnose" desirable and/or deviant electricity consumption patterns across nested scales from individual homes to entire utility grids. MFDFA and related nonlinear analyses of home energy consumptive use patterns may be useful in detecting under-performing homes, in diagnosing increased risk of building system failures, in improving smart grid supply and load balancing, and in evaluating the impacts of home energy improvements over time.

2.6. External Collaborators

Major external collaborators at various stages of this project included the following: (1) Acceleration.net; (2) Larry Liebovitch (Ph.D., Professor of Physics and Department of Psychology, Queens College City University of New York); (3) Nick Taylor (Ph.D. Student, UF School of Natural Resources & Environment); and (4) Jennison Kipp (Assistant In, UF Program for Resource Efficient Communities).

2.7. Benefits to the State of Florida

This project helped to benefit the State of Florida through the development of new collaborations, the awarding of new grants and contracts, and new proposals as summarized in the tables that follow.

2.7.1.New Collaborations

New collaborations		
Partner name	**Title or short description of the collaboration**	**Funding, if applicable**
Larry Liebovitch, Ph.D.	Larry was officially integrated into Hal's Ph.D. advisory committee as a "Special Member" from Queens College CUNY (http://people.qc.cuny.edu/faculty/Larry.Liebovitch/Pages/Default.aspx)	Not applicable
Djundi Tjindra	UF/PREC is providing intellectual, data sharing, and logistical support for a related master's thesis and Djundi is providing new insights and visualizations into residential energy consumption in relation to residential density and urban development pattern	Not applicable
Enes Hosgor (Carnegie Mellon University)	UF/PREC is in discussion with this potential collaborator on a variety of potential benefits from improved business incubation on home energy performance monitoring and consumer feedback tools and platforms.	Opportunities under consideration
EcoCity Partners	Active collaboration is ongoing in the development and submission of a grant proposal to the US DOE Better Buildings program.	Minimum of $50,000 over 3 years

FAIRWINDS Credit Union	As seeded by the Osceola Energy Initiative (OEI), an ARRA funded program, UF/PREC has entered a 10-year partnership with FAIRWINDS Credit Union to administer a 7-county, $5 million residential energy efficiency finance program.	Tied to revenue from the delivery of the loan program
Several Building Contractors	UF/PREC is currently building partnerships with building professionals to serve as "Participating Independent Contractors" in the loan program.	Tied to revenue from the delivery of the loan program
Building Media, Inc.	UF/PREC is in discussion with this potential collaborator on a variety of opportunities for market segmentation, outreach, consumer behavior change campaigns, and measurement and verification of performance results for energy efficiency strategies in the residential sector including the inputs, interactions, and outputs of asset and operational rating systems.	Opportunities under consideration
Various local and community banks in Florida	UF/PREC has approached multiple financial institutions for potential collaboration on energy efficient financing programs for building retrofits in the residential and light commercial sectors.	N/A
DwellGreen, Inc.	UF/PREC is in discussion with this potential collaborator on a variety of opportunities for market segmentation, outreach, consumer behavior change campaigns, and measurement and verification of performance results for energy efficiency strategies in the residential sector including the inputs, interactions, and outputs of asset and operational rating systems.	Opportunities under consideration
Simonton & McKinney	Same as above.	Same as above
University of Florida Shimberg Center for Housing Studies	Same as above	Same as above
Well Home (a business of Masco Home Services, Inc.)	Same as above.	Same as above

	(*Contact arose as a result of networking at the US DOE Building America National Technical Conference in Denver in August 2011 and via subsequent follow up*)	
Great Reward, LLC	Same as above. (*Contact arose as a result of networking at the US DOE Building America National Technical Conference in Denver in August 2011 and via subsequent follow up*)	Same as above
The Shelton Group, Inc.	Same as above. (*Contact arose as a result of networking at the US DOE Building America National Technical Conference in Denver in August 2011 and via subsequent follow up*)	Same as above
Navigant Consulting, Inc.	Same as above. (*Contact arose as a result of networking at the US DOE Building America National Technical Conference in Denver in August 2011 and via subsequent follow up*)	Same as above
Charlotte Software Systems	UF/PREC is in discussion with this potential collaborator on a variety of potential benefits from utilizing non-linear computational optimization for evaluating various energy efficiency and climate action strategies in the residential sector including the inputs, interactions, and outputs of asset and operational rating systems.	Same as above
Various local and community banks in Florida	UF/PREC has approached multiple financial institutions for potential collaboration on energy efficient financing programs for building retrofits in the residential and light commercial sectors.	N/A
Gainesville-Alachua County Association of Realtors® (GACAR)	Very preliminary discussion has begun on potential future collaboration on integrating residential asset and operational rating information into Multiple Listing Service (MLS) data and/or various local “green” real estate efforts.	N/A
Alachua County Department	Very preliminary discussion has begun on potential future collaboration on integrating residential asset and operational rating information into	N/A

of Growth Management	property appraiser data, building code enforcement data, and/or various local “green” building efforts.	

2.7.2.New Grants/Contracts

Grants / Contracts Awarded					
Title	**Agency**	**Reference Number**	**PI, Co-investigators and collaborators**	**Period of Performance**	**Funding awarded**
Homeowner Energy Interactive Tool Updates	Florida Department of Agriculture and Consumer Services (FDACS) Office of Energy	PO #: S-4200-D1913	PI: Hal Knowles Internal Collaborators: Nick Taylor, Craig Miller, Jennison Kipp, & Pierce Jones External Collaborators: Acceleration.Net	6 weeks (from August 17, 2015 – September, 30 2015)	$8,000
The BEERE Menu: Pre-Packaged Technology Retrofit Options for PACE Financing	US DOE Better Buildings	DE-FOA-0000829 CFDA #: 81.086	PI: EcoCity Partners Co-PI: Hal Knowles, Craig Miller, Nick Taylor Collaborators: Pierce Jones and Jennison Kipp	3 year	$128,420.89 (UF Subcontract portion on a $669,102 overall proposal)

Homeowner Energy Interactive Tool	Florida Department of Agriculture and Consumer Services (FDACS) Office of Energy	PO #: S-4200-A1553	PI: Nick Taylor Co-PI: Hal Knowles Internal Collaborators: Craig Miller, Jennison Kipp, & Pierce Jones External Collaborators: Acceleration.Net	3 months (from March 28, 2013 – June, 30 2013)	$34,650

2.7.3.New Proposals

Proposals						
Title	**Agency**	**Reference Number**	**PI, Co-investigators and collaborators**	**Funding requested**	**Project time frame (1 year, 2 years, etc.)**	**Date submitted**
Coming to Cultural Consensus: Residential Utility Bill Transparency, Personal Privacy, and Social Norms	Knight Foundation: Informed & Engaged Communities	News Challenge 2: Data[2]	PI: Hal Knowles Collaborators: Chris McCarty Nick Taylor, Ryan Davis	$160,000	18 months	June 20, 2012
University of Florida Integrative Science for	National Institute of Standards and	2011-NIST-NCGP-01	PI: James W. Jones	$7,228,352	5 years (Anticipated from 11/01/2011	April 4, 2011

[2] http://newschallenge.tumblr.com/

Sustainable Resources (ISSR)	Technology (NIST) Construction Grant Program (NCGP)	CFDA #: 11.618	Collaborators / Scientific Team: Wendy D. Graham, Pierce Jones, James C. Oliverio, James Sullivan	(Federal requested portion on total estimated project cost of $9,459,340)	to 10/31/2016)	
EnergyIT: Home Energy Use Software for Education, Comparison, and Evaluation	U.S. Department of Energy Office of Science	DE-FOA-0000508 CFDA #: 81.049 (FY 2011 SBIR/STTR Phase II Grant Applications)	PI: Pierce Jones Co-PI: Hal Knowles Collaborators : Jennison Kipp & Nick Taylor	$243,008 (UF Subcontrac t portion on a $992,020 overall proposal)	2 years (Anticipated from July 2011 – June 2013)	April 4, 2011
Gainesville Regional Utilities: On-Bill Energy Efficiency Financing Program Proposal	Gainesville Regional Utilities (Municipally Owned Utility)	N/A (Unsolicited proposal)	PI: Pierce Jones Collaborators : Hal Knowles, Craig Miller, Kathleen Ruppert, Nick Taylor,	$15,000 (UF Subcontrac t portion on a $80,000 to $135,00 overall proposal)	1 year (Option for annual renewal)	March 25, 2011

2. Goals and Objectives

The goals and objectives of this project were to apply mixed mode qualitative research and quantitative analysis methods to evaluate the opportunities and constraints of asset modeling, operational modeling, and dynamical modeling approaches to residential building performance analysis and consumer feedback. The first objective of the Qualitative Focus Group Research was to test the usability and efficacy of a website (http://gainesville-green) as recorded by users at individual computer terminals. The second objective of the Qualitative Research was to conduct semi-structured focus group interviews with key stakeholders to better understand the role of residential building operational feedback as a tool for conservation behavior changes.

The first objective of the Quantitative Time Series Analysis Phase One was to evaluate the statistical nature of short interval residential smart meter time series data. The second objective of Phase One was to compare the correlations between home size, vintage, and energy use with the new metrics of fractal complexity.

The first objective of the Quantitative Time Series Analysis Phase Two was to evaluate the characteristics and fluctuations of the sub metered energy use time series complexity for further insights into household dynamics across key system variables. The second objective of Phase Two was to correlate the complexities of ambient outdoor weather patterns to home energy use patterns.

3. Project Activities, Results, and Accomplishments

4.1. Introduction

Recent environmental, social, and economic challenges are fostering a wave of interest in maximizing energy efficiency and conservation (EE+C) in existing U.S. homes. Long standing programs, ratings, and metrics are being reapplied into new stimulus initiatives such as the Recovery through Retrofit program. Simultaneously, electric and gas utilities are expanding their demand side management (DSM) programs from weatherization and conventional technology replacement incentives to include conservation behavior campaigns with “recommendation algorithms” designed to assist in homeowner energy retrofit decision making. Furthermore, loan programs are emerging to address the financial barriers that commonly limit initiation of the necessary retrofits.

Collectively, these approaches most often project future home energy performance based on engineering models of the physical characteristics of homes (i.e., “asset ratings”). Yet to date, the marketplace is inadequately integrating historical household energy consumption patterns (i.e., “operational ratings”) into the decision tree to optimize retrofit program efficacy and consumer benefits. Moving toward the unification of asset and operational ratings is crucial for successful program management, proper monitoring/measurement/verification (MMV), loan risk assessment, and for the persistence of reduced home energy use over time.

However, unification will not be easy. This research project combines qualitative focus group research and quantitative time series analysis methods in social science and building science using Florida case studies to evaluate the opportunities and constraints of asset and operational rating unification and the steps necessary to get there.

The two phases of quantitative time series analysis expand on themes and insights gained through the qualitative focus group research efforts. Specifically, these qualitative insights suggest that even when adding operational data to building asset data, the reductionist approach to

evaluating home energy performance by controlling for known variables may continue to offer an incomplete picture of the complexities of performance trends and the influence of unknown and/or misunderstood variables. Furthermore, the home improvement industry may need to consider the possibility that the magnitude of total energy consumption, while a worthwhile metric and with its net reduction a worthwhile goal, is also an incomplete indicator of home energy performance optimization.

4.2. A Fractal Vocabulary

To paraphrase Albert Einstein, “we cannot solve today’s problems with yesterday’s thinking.” By their very name, normal statistics and linear dynamics are rooted in a scientific conventional wisdom that assumes nature behaves as a straightforward sum of its parts. This research suggests that new thinking, and new solutions, await us in other dimensions…fractal dimensions.

For example, Florida is a fractal shaped peninsula. There is no single measure of length to describe the Florida coast. As our ruler gets ever smaller, the coast of Florida appears ever longer, revealing increasingly more subtle details. Now imagine the challenge of using this same coarse-grained ruler to capture the shape of a tree. These objects, and the systems that generate them, are too complex to be described by the 0 dimensional points, 1 dimensional lines, 2 dimensional planes, and 3 dimensional solids of Euclidean geometry, nor the Gaussian distribution of normal statistics.

Fractals are rough, self-similar, and branch iteratively across space, but also within time. Like Goldilocks, our lungs respire, our brains fire, our postures sway, and our hearts beat with resilient fractal complexities that are neither too simple and regular nor too disordered and irregular. At our healthiest, we are adapted for uncertainty and prepared to change in response to our dynamic surroundings.

4.3. Fractal Complexity: A New Dynamical Building Performance Indicator?

Zellmer et al. (1) suggest, “complexity is not a material property, but turns rather on the question that is posed” and the narratives we create and share in an effort to make systems explicable. Fractal dimension, a nonlinear dynamical measure of a system’s complexity, has linkages to power law scaling (2,3) and can be used to partially explain variability in diverse time series signals, such as: seismic activity along geologic fault lines (4–8), stock indices of financial markets (9–16), electricity demand of utility grids (17–25), and rate changes of human physiological control networks (26–37).

It is hypothesized by some that disease and systemic inefficiency may be defined by a change in complexity (as reflected within system signal variability) and not the conventionally believed loss of regularity. For example, within the healthcare arena, human disease may be “dynamic” as indicated by examples such as a physiological control network shifting from one nonlinear stable state into another (26,38,39) or by changes in the fractal pattern of a cell membrane and thus an alternation of its disease potential (40–44). In other words, fractal dimension analysis may shed light on the transition from normal to pathological rhythms in diverse time series events thus providing a dynamic diagnostic signal for the health of the system under scrutiny.

It could be argued that the electricity grid is akin to a social physiological control network designed to reliably provide the continuous energy flows required by modern buildings despite fluctuations in weather and fuel costs. If accurate, this metaphor may also suggest that the time series variability of disaggregated energy consumption at the scale of an individually metered building may have its own nonlinear pattern of good health or dynamic disease.

The fluid and continuous nature of energy consumption is a macroscopic phenomenon resulting from the microscopic interactions of not only a building's energy consuming devices, but also the physical nature of the building structure and its thermal management systems as well as the nearly infinite variables of social behavior and human comfort. "A salient feature of nonlinear systems is that their components interact with each other, and therefore their outputs are not proportional to the strength of the inputs" (45).

4.4. Methods: Qualitative Focus Group Research Component

Qualitative website (Figure 1) usability testing and semi-structured interview survey questions on key asset and operational rating criteria and their interactions were developed for a series of focus group sessions conducted in February and March, 2011. These sessions explored household utility service information needs and the usability of a home energy and water reporting website (http://gainesville-green.com/) for customers within the Gainesville Regional Utilities service territory (University of Florida IRB-02 #2011-U-0003).

Figure 5. The homepage of the Gainesville Green home energy and water consumption consumer feedback tool.

4.4.1. Major Interview Topics

Though these sessions were funded under a separate grant project, the integration of asset and operational rating issues into the research design was made possible by this FESC project. Major topics addressed included: (1) the website's task support capacity enabling users to meet their home energy performance goals; (2) ease, efficiency, and intuitiveness of website use; (3) aesthetics of the graphical user interface; (4) relevance of information presented by user group

need; and (5) knowledge, attitudes, and/or beliefs on home energy issues and conservation behaviors.

4.4.2. Mixed Mode Interviews

Our mixed-mode approach combined individual human-computer interface (HCI) usability testing ranging from 30-53 minutes, immediately followed by semi-structured focus group interviews ranging from 54 to 78 minutes. Participants were recruited using a combination of non-probabilistic convenience sampling and snowball sampling of key informants within our six identified stakeholder groups. Wherever possible, we focused on recruiting participants with an interest in home energy performance as they are the most likely users of our website. These participants included homeowners involved in local environmental initiatives, homebuilders who participate in programs like Energy Star and/or Building America, certified home energy raters, real estate agents and brokers involved in local green building sales efforts, and financial industry stakeholders with knowledge about energy efficient mortgages and lending processes.

4.4.3. Participant Benefits

Participants were provided the following free "tokens of appreciation" for their participation in the usability testing and focus groups:

a. A one-page (front and back) quick reference guide for GRU energy efficiency rebates and programs. (Note: Donated by GRU)

b. Two compact fluorescent light bulbs. (Note: Donated by GRU)

c. Handbook –"Options for Clean Energy Financing Programs: Scalable Solutions for Florida's Local Governments." (Note: Donated by the University of Florida Program for Resource Efficient Communities – http://buildgreen.ufl.edu/FloridaGuide_order.pdf)

4.4.4. Usability Testing

Usability testing was developed and deployed as influenced by industry trends and experience (46,47). As such, we used separate waves of small groups of individuals allowing for refinements to the website after each wave. Participants sat at a separate individual computer terminal in the training room of the University of Florida Survey Research Center. Participants were asked to follow a series of ordered scenarios and tasks while "thinking out loud" by speaking into headset microphones as they worked through the tasks and moved through the website.

4.4.5. Focus Group Structure

Seven focus group interviews were based on the methods and principals espoused in Richard Krueger's six characteristics of focus groups as detailed in the points below (48).

1. Small Groups of People – With mini-focus groups typically consisting of four-to-five individuals and conventional focus groups consisting of six-to-twelve individuals, we aimed for a minimum of four and a maximum of eight participants in each of our seven sessions. This size range was determined to provide an optimal mix of "opportunity to share ideas" while still maintaining a sufficient overall "pool of ideas" across a diversity of potential user groups.

2. Conducted in Series – In order to maximize the opportunity for pattern detection across and within diverse stakeholder groups we held seven separate group sessions over a three week period. These seven sessions consisted of six different stakeholder types, though one stakeholder type had two separate groups. The group types, session names, and number of respective participants are shown below in the order in which they were conducted.

    a. Homebuilders (Group 1): 6 Participants

    b. Homeowners: 5 Participants

    c. Realtors®: 7 Participants

    d. Local Government Staff/Officials: 6 Participants

    e. Home Energy Raters/Auditors: 4 Participants

    f. Homebuilders (Group 2): 4 Participants

    g. Bankers/Loan Originators: 5 Participants

3. Homogeneous – Focus groups function best when participants share similarities in the traits and subject matter under investigation. We choose to categorize and group our stakeholder types according to homogeneity in the particular perspective we believed they would bring to the discussion. Though we only held one specific home owner group, we asked all of the other professional/trade groups to wear “two hats” during their sessions. The main hat, and thus their most important perspective, would be that of their profession/trade, while their secondary hat would be that of a homeowner/renter.

4. Data Collection – Our focus groups were designed to support our website usability testing and to gather additional insights into how utility consumptive use data and visual analytics might inform and motivate various stakeholder groups that interface with the homebuilding, home buying, home owning, and mortgage lending processes.

5. Qualitative in Nature – As Krueger (48) describes, our process was not to build consensus but rather “to determine the perceptions, feelings, and manner of thinking of consumers regarding products, services, or opportunities.” Our research team utilized a semi-structured open-ended group discussion facilitation approach designed to provide qualitative data that will be inductively analyzed to help immediately improve the website design and function, as well as to lay the foundation for the creation of a quantitative survey instrument to be developed and deployed for a more randomized and generalizable application in future research projects. All focus groups were audio recorded. Transcriptions for both the usability tests and the focus groups will be undertaken in future research to enable qualitative data analysis (QDA) using the ATLAS.ti 6.2 software suite. Text coding, pattern recognition, and other QDA approaches will be used to perform a complete analysis to both pursue publication in a peer-reviewed journal as well as to inform the development of the quantitative survey instrument.

6. Focused Discussion – Merging a mixed-mode evaluation approach allowed for the usability testing scenarios to serve as a predetermined, but flexible, interview guide for the focus group discussions. These scenarios and their associated tasks were developed to be logical and understandable to the stakeholders without providing a detailed step-by-

step guide to the website. These scenarios placed participants in situations that we believe may occur with the diverse users of the website. More specifically, these scenarios were a guide, not rules, which allowed our testing participants an opportunity to flow through the site and use its various features on their own terms (meaning sometimes with clarity and certitude and sometimes with confusion and frustration depending on how well the site serves their needs).

4.5. Methods: Quantitative Time Series Analysis Component

Two data sets were analyzed: (1) 15-minute interval electric readings for approximately 350 homes and apartments in a random sample the JEA service territory of Jacksonville, Florida; and (2) hourly interval electric readings for 60 Florida homes in the Phased Deep Retrofits (PDR) program of the Building America – Partnership for Improved Residential Construction.

4.5.1. Normality Testing

First, normality testing was performed on the time series. Normality testing included the evaluation of histogram distributions for skewness and kurtosis, probability-probability (P-P) plots for linear trend line fitness, and quantile-quantile (Q-Q) plots for linear trend line fitness.

4.5.2. Multifractal Detrended Fluctuation Analysis (MFDFA): Whole House Meters

Second, multifractal detrended fluctuation analysis (MFDFA) was performed on the original increments (49), shuffled surrogates (50), and phase randomized surrogates (50) of these time series (50). MFDFA describes "scaling behavior of noisy data in the presence of trends without knowing their origin and shape" (50). The two major sources of fractality in times series data are: (1) long-range temporal correlations and clustered volatility; and (2) fat-tailed probability distributions of increments between data readings.

The purpose of applying the MFDFA methods to both the original increments, as well as two key surrogates, is to measure the contribution and strength of the two major sources of fractality. Shuffling the original data destroys any original temporal correlations, but preserves any original increment distributions. Phase randomization of the original data destroys any original increment distributions, but preserves any original temporal correlations.

4.5.3. Multifractal Detrended Fluctuation Analysis (MFDFA): Sub Meters and Weather

Third, MFDFA was performed on the original and surrogate increments of various 15-minute interval weather time series and the disaggregated electric sub-meters of major home systems in the PDR (e.g., heat pump compressor, air handling unit, refrigerator, freezer, water heater, lighting circuit, home A/V system circuit, pool pump).

4.5.4. Cluster Analysis

Fourth, cluster analysis was used to segment and compare the fractality of the homes and the weather. Matlab cluster visualization and evaluation tool was used. More specifically, four k-means clustering methods were run to evaluate what number of clusters seemed most descriptive of the distribution of MFDFA results: (1) Calinski Harabasz Values; (2) Davies Bouldin Values; (3) Gap Values; and (4) Silhouette Values.

4.6. Results: Qualitative Focus Group Research Component

Approximately 1,500 minutes of individual usability testing audio feedback for 37 separate individuals and 440 minutes of focus group audio feedback for 7 separate stakeholder groups was collected. Based on the focus group interviews, having a meaningful home energy use point of comparison is essential. In fact, it may be the most essential criteria of home energy feedback. Every focus group stated that “apples to apples” comparisons are necessary. All stakeholder groups expressed concern that “other” people may be misled by the feedback and draw invalid conclusions. Yet our research team found this interesting because of the implication that “others” would clearly confuse or misunderstand something that virtually all individual stakeholders recognized – that human behavior within buildings can have a profound and confounding effect on utility consumption patterns.

Preliminary findings from these qualitative data provided a foundation for the quantitative time series analysis component of this research and for an in-depth inclusion of asset and operational rating considerations into a significantly larger grant proposal as detailed in the “Funds Leveraged” section. Additional collaborations are being developed.

4.7. Results: Quantitative Time Series Analysis Component

Through the availability of short interval residential smart meter data and the application of multifractal detrended fluctuation analysis (MFDFA), this research suggests alternative methods to evaluate home energy consumption patterns and may inform new narratives to engage utility customers in verbal, written, and graphical forms. Most importantly, applying nonlinear statistical models to these higher resolution data offers deeper insights into the visibly complex dynamics of residential building performance and human occupancy. While additional research is needed to confirm our findings, we believe that the conventional wisdom on the role and relationship of common building assets and operational human behaviors may need to be reconsidered. Our findings are detailed as follows.

4.7.1. Home Energy Use is Non-Normal

Home energy use is non-normal, non-stationary, leptokurtic, and displays positive (right) skewness. High skewness (degree of symmetry in the probability distribution function) and leptokurtosis (taller, narrower central spike; shorter, flatter shoulders; and fat tails in the probability distribution function) suggest higher distribution of extreme events when compared to the normal Gaussian bell curve. A normally distributed random variable should have skewness and kurtosis near zero and three, respectively. Exemplified by Home #91 (Figure 2), this histogram displays a distribution with a right skewness of 2.08 and a kurtosis of 5.10. Both of these values suggest non-normality.

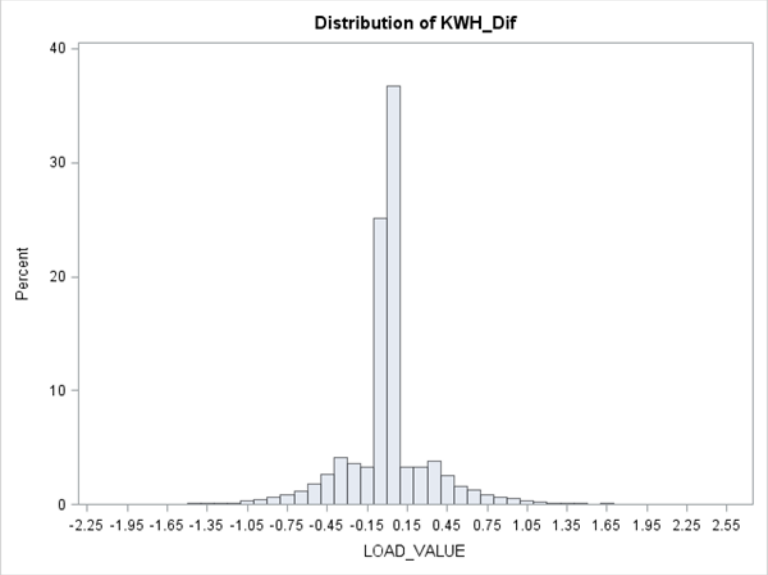

Figure 6. JEA Home #91 histogram distribution.

A probability-probability (P-P) plot compares an empirical cumulative distribution function of a variable with a specific theoretical cumulative distribution function (e.g., the standard normal distribution function). Deviations from the theoretical line suggest non-normality. Exemplified by Home #91 (Figure 3), this P-P plot expresses significant deviation from a linear fit line. This nonlinear fit suggests non-normality.

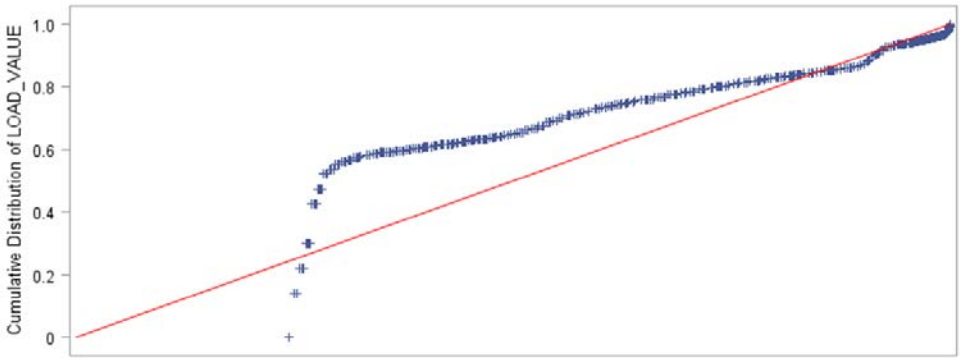

Figure 7. Home #91 probability-probability (P-P) plot.

A quantile-quantile (Q-Q) plot compares ordered values of a variable with quantiles of a specific theoretical distribution (i.e., the normal distribution). If two distributions match, the points on the plot will form a linear pattern passing through the origin with a unit slope. Exemplified by Home #91 (Figure 4), this Q-Q plot expresses significant deviation from a linear fit line. This nonlinear fit suggests non-normality.

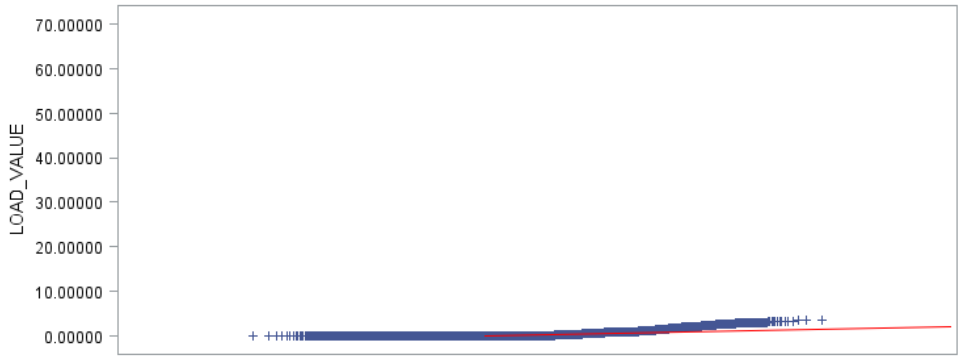

Figure 8. JEA Home #91 quantile-quantile (Q-Q) plot.

All too often, we view these non-normalities as outliers which "mess" up our analysis, so we screen and clean them out of the data in an attempt to apply linear statistics. As such, we may be throwing out some of the most diagnostically valuable system readings from the entire dataset. These findings suggest that linear statistical methods and building performance models founded upon a presumption of normality and Gaussian distributions of time series energy consumption increments are likely inappropriate. Given the higher resolution and larger data sets available from short interval smart meter readings, nonlinear methods appear more appropriate.

4.7.2. Home Energy Use is Multifractal

Upon the application of multifractal detrended fluctuation analysis (MFDFA), home energy use appears multifractal with long-range temporal correlations. More specifically, evidence of multifractality includes the following: (1) *Tq* values have a nonlinear trend fit; (2) *Hq* values are dependent on *q* values; (3) MFDFA spectra are reasonably wide; (4) Long right tails from truncation and leveling of *q* when $q > 0$ (i.e., MFDFA structure insensitive to local fluctuations with large magnitudes); and (5) Generalized Hurst exponents are < 0.5 (i.e., suggests anti-persistent trend at all *q* values).

General Principles of Multifractal Detrended Fluctuation Analysis (49)

- Generalized Hurst exponent, *h(q)*, describes scaling behaviors of the time series
  - Segments with large fluctuations when $q > 0$
  - Segments with small fluctuations when $q < 0$
- Time independent trends (white noise) = H ~ 0.5
- Persistent trends = H > 0.5
  - Increments are correlated
  - Past decreases more likely to be followed by future decreases (& vice-versa)
- Anti-persistent trends = H < 0.5
  - Increments are anti-correlated
  - Past decreases more likely to be followed by future increases
- Fractal systems
  - Monofractal
    - *h(q)* independent of *q* order
    - *T(q)* plots linearly
  - Multifractal
    - *h(q)* dependent of *q* order
    - *T(q)* plots nonlinearly (with increasing nonlinearity suggesting stronger multifractality)

- Shuffling
    - If *h(q)* = 0.5 and loses wide spectra, then multifractality is influenced by strong temporal correlations
- Phase randomization
    - If *h(q)* becomes independent of *q* but maintains similar *h(2)*, then multifractality is influenced by fat-tailed probability distribution functions
- If both shuffling & phase randomization show multifractality, but weaker than original signal, then both sources of multifractality are present
- Truncation
    - Long right tail
        - Leveling of *q* when $q > 0$
        - Multifractality is insensitive to local fluctuations with large magnitudes
    - Long left tail
        - Leveling of *q* when $q < 0$
        - Multifractality is insensitive to local fluctuations with small magnitudes

4.7.3. Phase One Examples of MFDFA Results for JEA Home #91

As exemplified by JEA Home #91 and explained in the previous section, original increments express multifractality (Figure 5). Analysis of the shuffled increments (Figure 6) and the phase randomized increments (Figure 7) suggests that home energy use is primarily influenced by strong long-range temporal correlations. However, the presence of a shorter left tail on the MFDFA spectrum suggests that the multifractality contains a smaller, secondary sensitivity to local fluctuations with large magnitudes in the probability distribution of the original increments (Figure 8). In other words, the dynamics of this home's energy use are primarily driven by temporal relationships of variables across time, however there is a smaller, secondary driver from the fat tailed distribution of the largest energy use increments.

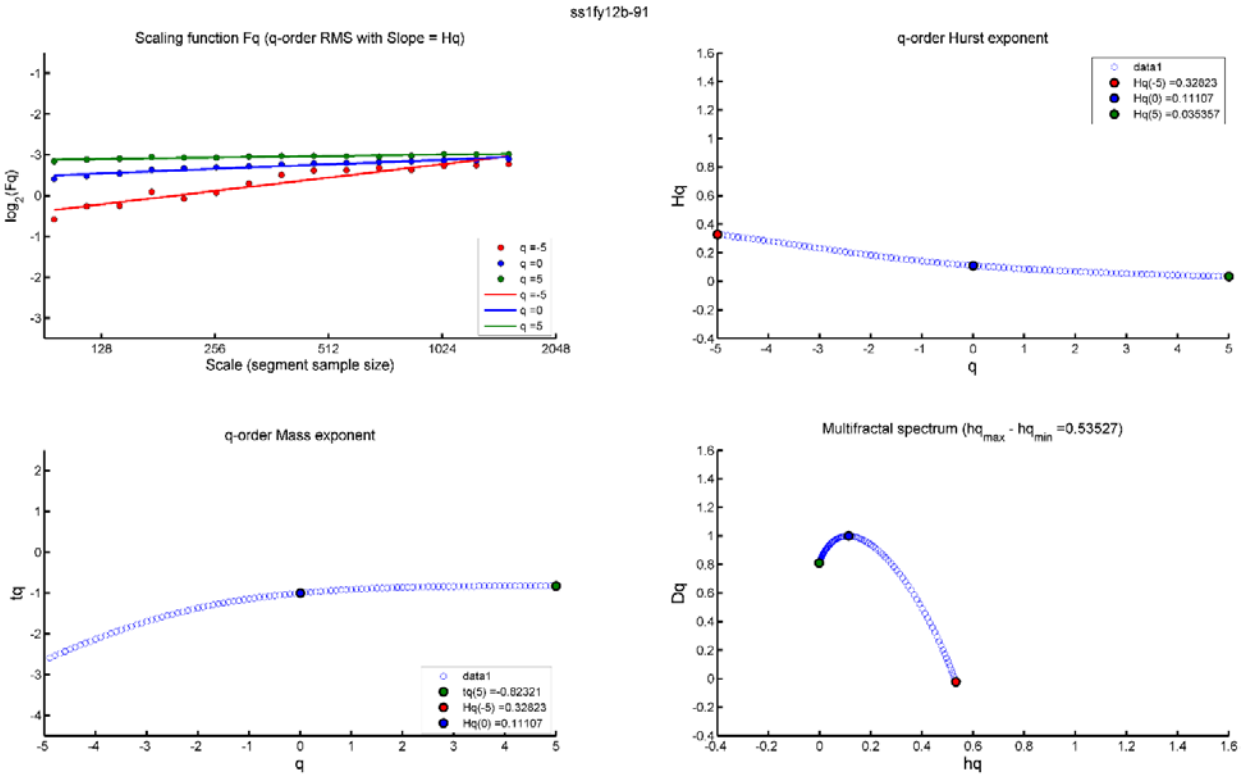

Figure 9. JEA Home #91 MFDFA output for original increments of 15-minute interval energy consumption.

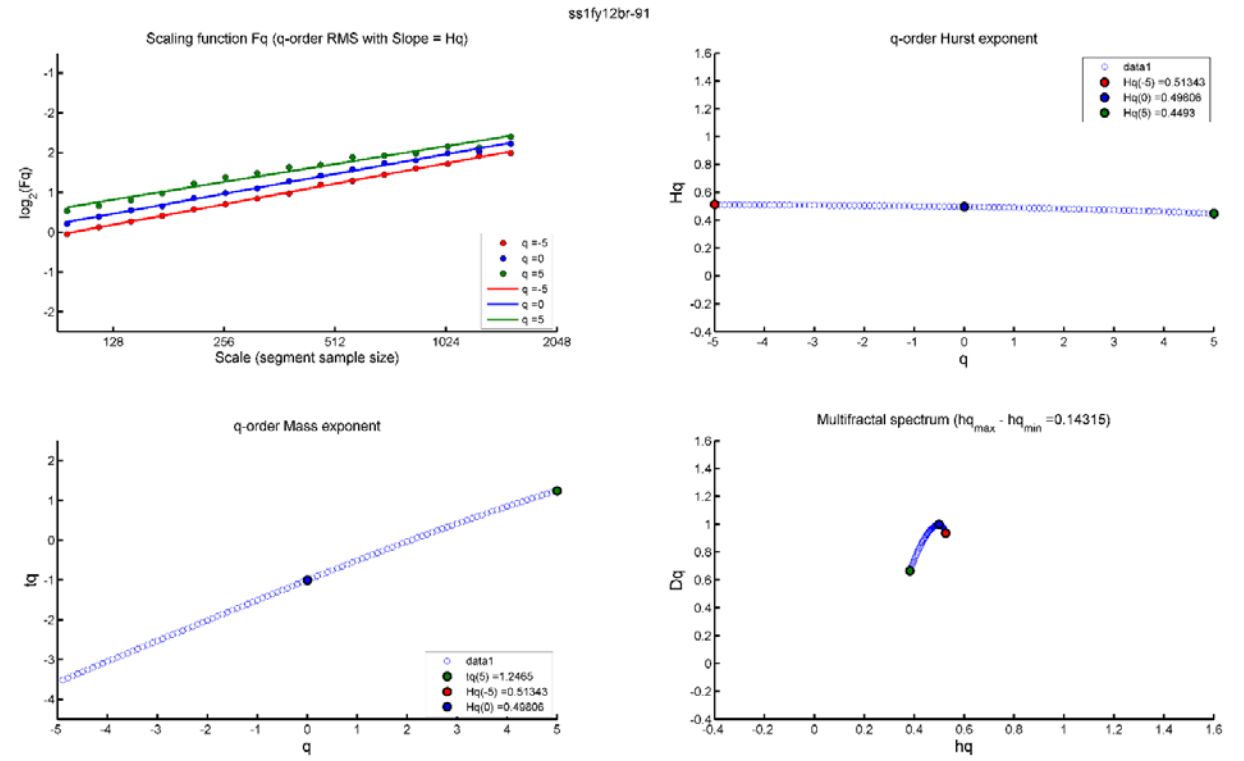

Figure 10. JEA Home #91 MFDFA output for shuffled increments of 15-minute interval energy consumption.

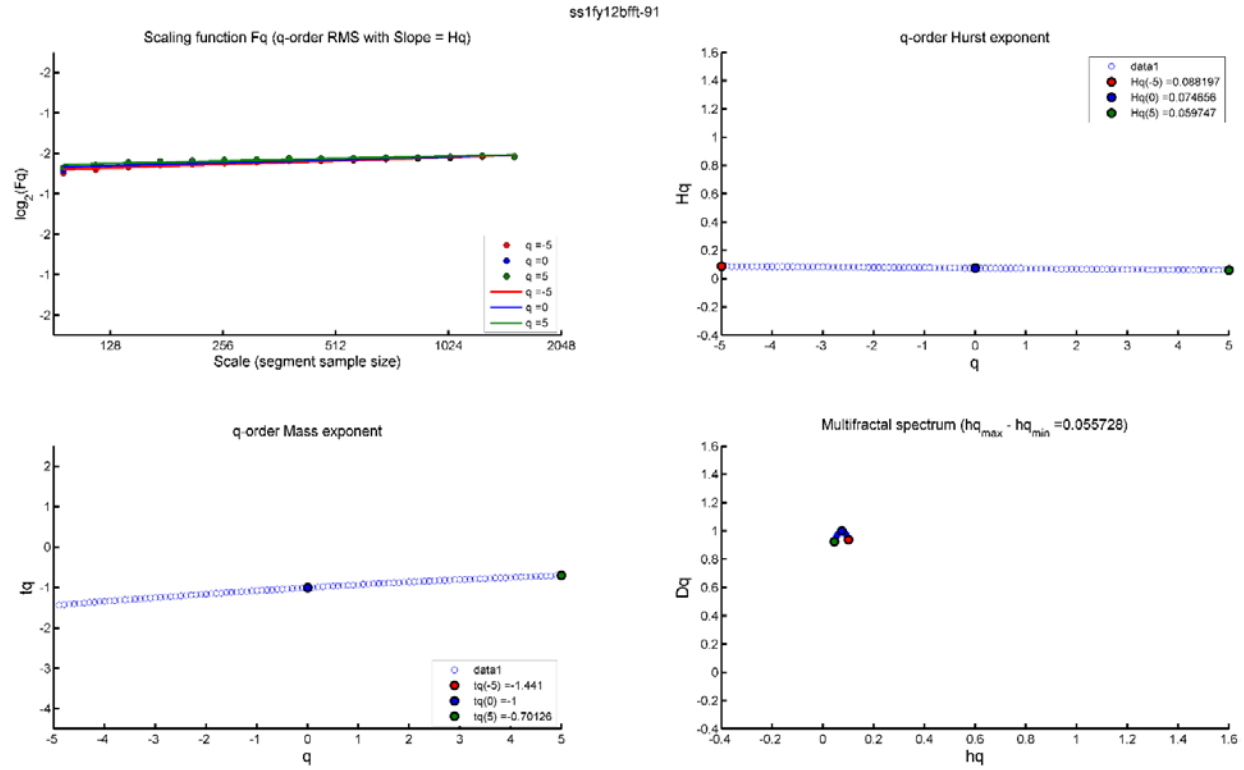

Figure 11. JEA Home #91 MFDFA output for phase randomized increments of 15-minute interval energy consumption.

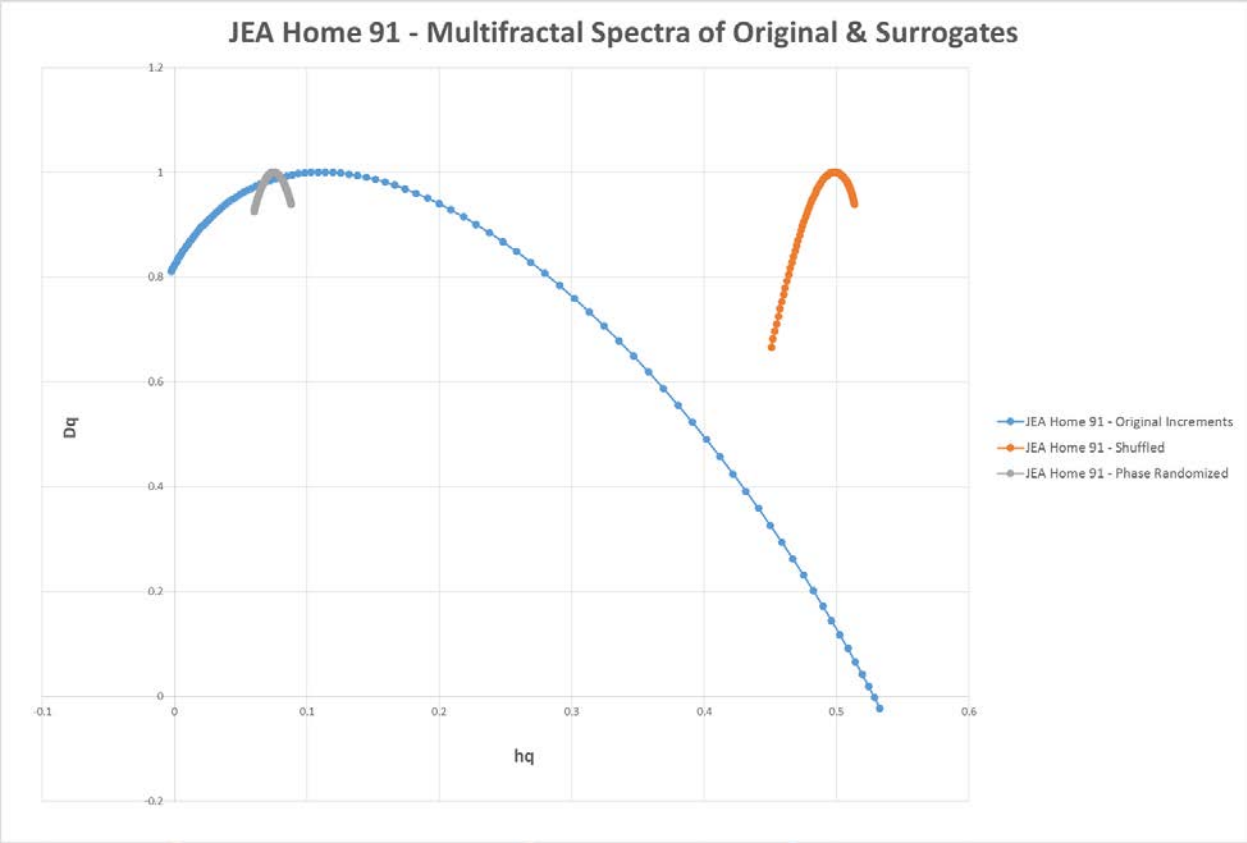

Figure 12. JEA Home #91 comparison of MFDFA spectra for original, shuffled, and phase randomized increments.

4.7.4. Home Energy Use Complexity is More Descriptive of System Dynamics than Conventionally Presumed Variables

Cluster analysis suggests that the fractal complexity across all homes in the JEA data set is more descriptive of individual home system dynamics than the conventional wisdom key variables of kWh (mean, variance, and sum), home size (square feet), and home vintage (year built). The importance of this finding cannot be understated as it suggests that the presumptions used to generate most asset and operational models of home performance are found to be incorrect when larger, more highly resolved data is available.

4.7.5. Example of Cluster Analysis Results

To further explain this finding, Figure 9 compares the complexity of energy use (via the *hq* value of the MFDFA on the y-axis) to the total sum of energy use (in kWh on the x-axis), the size of homes (in square feet on the circle diameter of home dots), and the vintage of homes (by decade built in the 1950s, 1960s, and 1970s). As evidenced in the chart, similar homes (i.e., alike cluster colors and numbers) appear more tightly correlated with the complexity variable than the sum, size, and vintage variables.

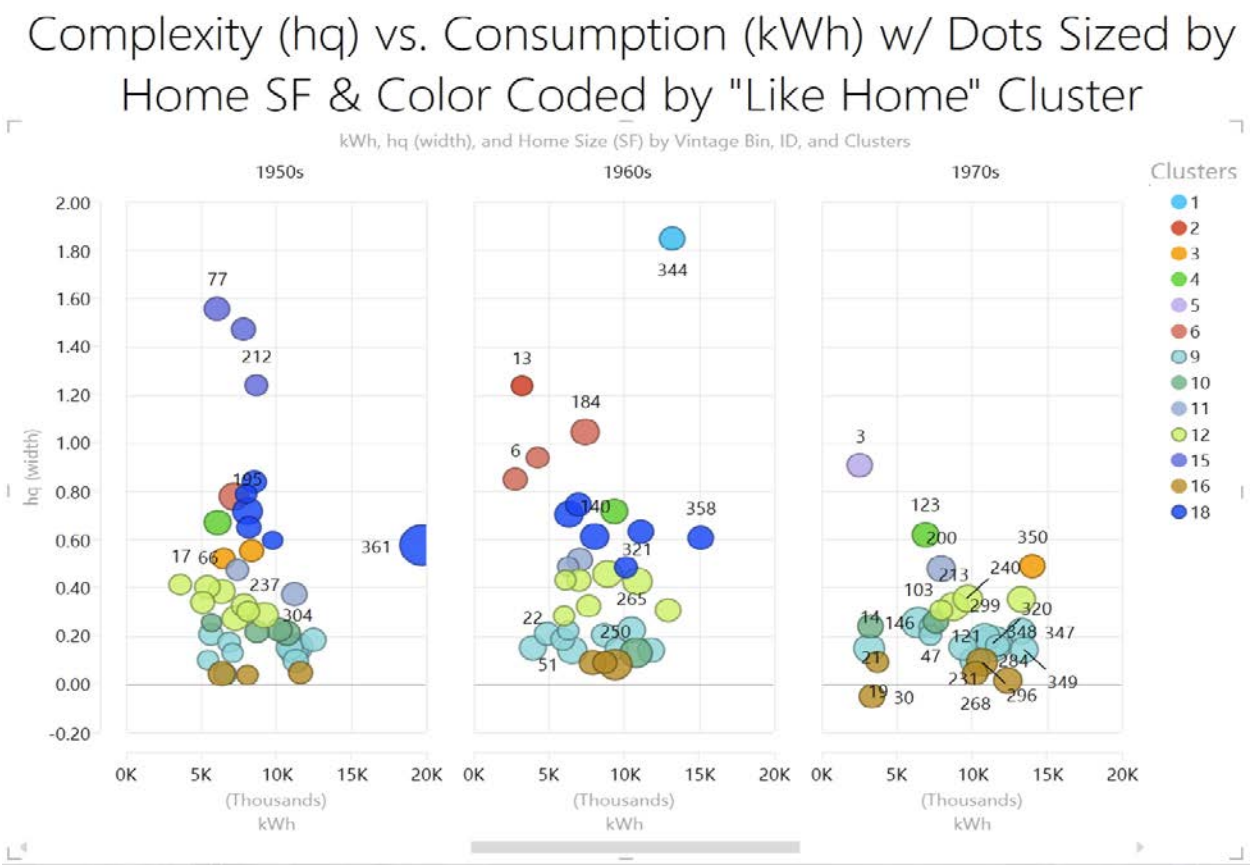

Figure 13. A sampling of JEA homes showing color coded clusters of like homes.

4.7.6. Phase Two Example of MFDFA Results for PDR Home #26

While Phase Two of the Quantitative Time Series Analysis was only partially completed during the funded period of this FESC project. However, preliminary MFDFA spectra suggest that behaviorally influenced variables may correlate with higher complexity in time series patterns, though further analysis is necessary for a more generalizable confirmation. As exemplified by PDR Home #26 (Figure 10), lighting energy use (presumably behaviorally driven), is significantly more complex than mechanical systems (e.g., refrigerator, HP compressor).

Additionally, preliminary sub-daily (Figure 11) vs. supra-daily (Figure 12) MFDFA singularity spectra suggest both weather and home energy consumption patterns may be driven by different dynamics within days versus across days. As exemplified in the FAWN Station #180, the sub-daily MFDFA of temperature increments are both more complex and more persistent than the supra-daily MFDFA. This makes sense as temperatures tend to steadily rise and then fall over the course of a single diurnal cycle (thus the persistent signal), whereas temperatures appear to trend more anti-persistently between days. Overall, the shape and magnitude of the MFDFA singularity spectra offer a proxy for the complexity of the house as a social-technological system with a mix of known and unknown variables.

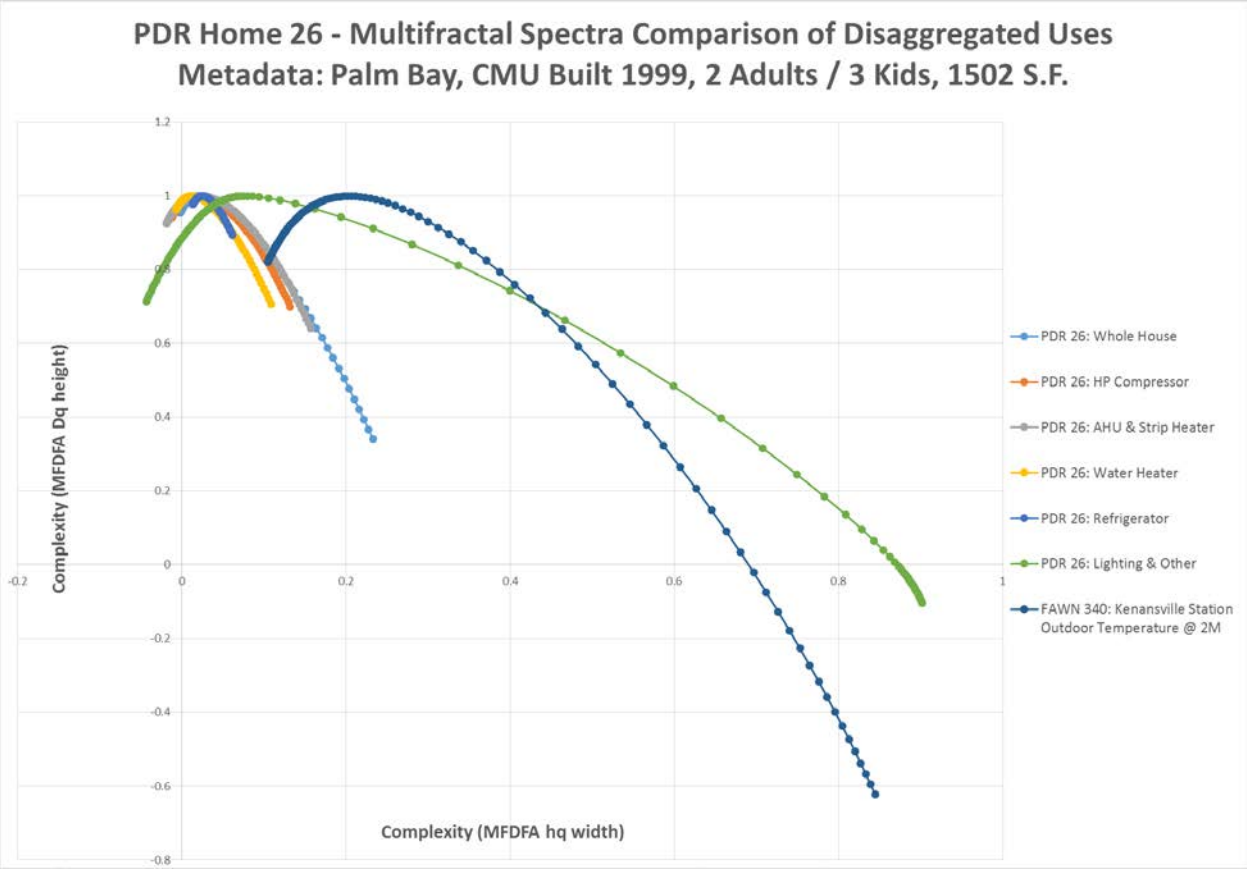

Figure 14. PDR Home #26 MFDFA spectra comparison of disaggregated sub-metered home energy uses.

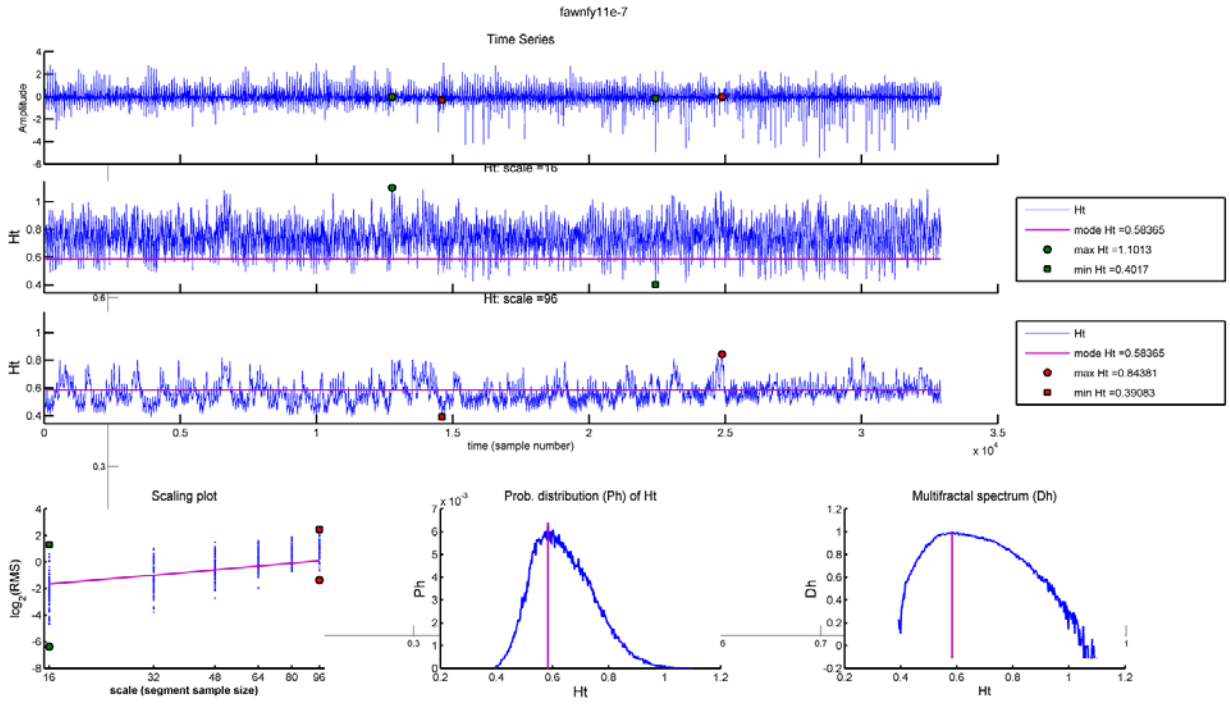

Figure 15. Florida Automated Weather Network (FAWN) Station #180 sub-daily (scales < 96 readings)) MFDFA output for original increments of 15-minute interval temperatures at 2 meters above the ground.

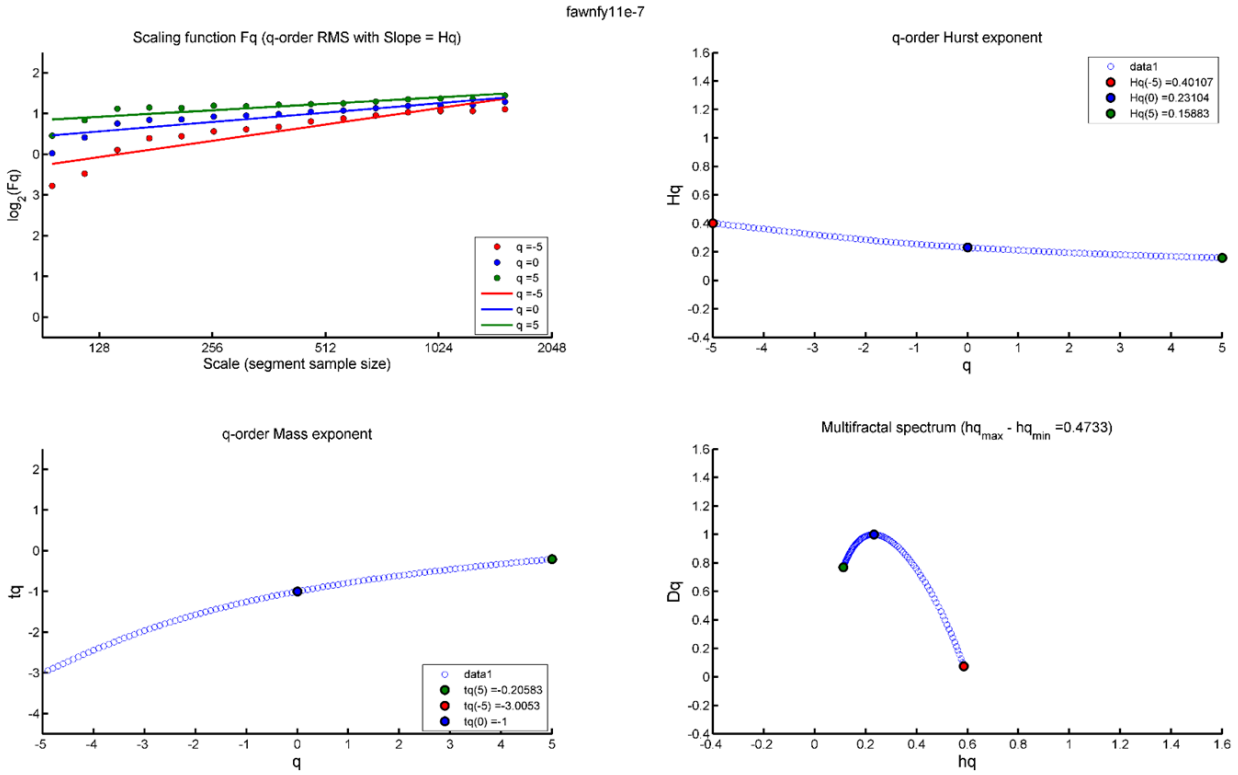

Figure 16. Florida Automated Weather Network (FAWN) Station #180 supra-daily (scales > 96 readings) MFDFA output for original increments of 15-minute interval temperatures at 2 meters above the ground.

4.8. Discussion and Accomplishments

4.8.1. Ghosts of Green Building: Past

Our past thinking assumed buildings were simple machines, with known variables, whose performance could be perfectly engineered. We measured energy use in monthly billing intervals and differentiated the good from the bad by the normal statistics of means, variances, and sums.

Yet the predicted outcomes from this asset modeled approach to building performance were often wrong …sometimes wildly. What was their fatal flaw? We forgot that all machines have both programmers and users.

4.8.2. Ghosts of Green Building: Present

Our present thinking integrates human behavior into the equation. Human plus machine turns house into home. We now assume, that with enough due diligence, we can integrate these

behavioral variables into our operational models and reengineer our homes accordingly. Or so we think…and therein lies the problem.

We measure our building performance and occupant behavior with a coarse-grained ruler that fails to describe the dynamics of our ever-evolving lives. We have simply boxed our human nature into a clockwork concept of the original machine, as if robots are the operators.

4.8.3. Ghosts of Green Building: Future

Our future thinking will use dynamical models to treat our buildings as organisms and our cities as ecosystems. If Pliny the Elder was right, and home is where the heart is, then the state of home health may hide in the space between its beats. As such, this research applies the science of chaos, nonlinearity, and fractal physiology to describe, diagnose, and improve home performance from electric smart meter data as if this signal is the heartbeat of the home.

4.8.4. Potential Uses of MFDFA as Smart Meter Data Becomes More Common

Based on the preliminary findings from this research, we believe that MFDFA and related nonlinear analysis methods may usher in a new wave of building performance rating and feedback tools and improve the unification of asset and operational models into more dynamical models. Three general categories of potential uses for these methods include decision support, customer service, and smart grid management within the utility industry.

4.8.4.1 Potential Decision Support Uses

MFDFA may enable comparative energy analytics within and across homes, even in the absence of building asset data as this approach does not require assumptions be made about known or unknown building asset variables. MFDFA may also generate complexity-based categorizations of home performance intervention outcomes independent of pre- vs. post-intervention changes in total kWh.

4.8.4.2. Potential Customer Service Uses

MFDFA may improve utility customer segmentation and targeting of home performance interventions by more accurately clustering homes based on their complex system dynamics rather than presumptions of known variables such as annual energy use, home size, and home vintage. MFDFA may also improve the diagnosis of increased risks of building system failure as measured by the loss of energy use complexity across time.

4.8.4.3. Potential Smart Grid Management Uses

MFDFA may improve the short-term predictive capacity of energy use patterns for supply and load balancing and volatility management of an increasingly distributed grid. MFDFA may also improve the estimation of risk potentials of grid-level energy demand spikes based on the shifting nonlinear dynamics of weather and/or energy use complexity.

5. Concluding Remarks

Through literature reviews, direct qualitative focus group research and quantitative analysis, industry outreach, networking, and a variety of related channels, this FESC project has helped to inform the building science community and utility industry. Furthermore, this project has been

leveraged into multiple proposals and fostered a diversity of potential collaborations and next steps for future work.

5.1. External Collaborators

Major external collaborators at various stages of this project included the following: (1) Acceleration.net; (2) Larry Liebovitch (Ph.D., Professor of Physics and Department of Psychology, Queens College City University of New York); (3) Nick Taylor (Ph.D. Student, UF School of Natural Resources & Environment); and (4) Jennison Kipp (Assistant In, UF Program for Resource Efficient Communities).

5.2. Benefits to the State of Florida

This project helped to benefit the State of Florida through the development of new collaborations, the awarding of new grants and contracts, and new proposals as summarized in the tables that follow.

5.2.1. New Collaborations

New collaborations		
Partner name	**Title or short description of the collaboration**	**Funding, if applicable**
Larry Liebovitch, Ph.D.	Larry was officially integrated into Hal's Ph.D. advisory committee as a "Special Member" from Queens College CUNY (http://people.qc.cuny.edu/faculty/Larry.Liebovitch/Pages/Default.aspx)	Not applicable
Djundi Tjindra	UF/PREC is providing intellectual, data sharing, and logistical support for a related master's thesis and Djundi is providing new insights and visualizations into residential energy consumption in relation to residential density and urban development pattern	Not applicable
Enes Hosgor (Carnegie Mellon University)	UF/PREC is in discussion with this potential collaborator on a variety of potential benefits from improved business incubation on home energy performance monitoring and consumer feedback tools and platforms.	Opportunities under consideration
EcoCity Partners	Active collaboration is ongoing in the development and submission of a grant proposal to the US DOE Better Buildings program.	Minimum of $50,000 over 3 years
FAIRWINDS Credit Union	As seeded by the Osceola Energy Initiative (OEI), an ARRA funded program, UF/PREC has entered a 10-year partnership with FAIRWINDS Credit Union to administer a 7-county, $5 million residential energy efficiency finance program.	Tied to revenue from the delivery of the loan program

Several Building Contractors	UF/PREC is currently building partnerships with building professionals to serve as "Participating Independent Contractors" in the loan program.	Tied to revenue from the delivery of the loan program
Building Media, Inc.	UF/PREC is in discussion with this potential collaborator on a variety of opportunities for market segmentation, outreach, consumer behavior change campaigns, and measurement and verification of performance results for energy efficiency strategies in the residential sector including the inputs, interactions, and outputs of asset and operational rating systems.	Opportunities under consideration
Various local and community banks in Florida	UF/PREC has approached multiple financial institutions for potential collaboration on energy efficient financing programs for building retrofits in the residential and light commercial sectors.	N/A
DwellGreen, Inc.	UF/PREC is in discussion with this potential collaborator on a variety of opportunities for market segmentation, outreach, consumer behavior change campaigns, and measurement and verification of performance results for energy efficiency strategies in the residential sector including the inputs, interactions, and outputs of asset and operational rating systems.	Opportunities under consideration
Simonton & McKinney	Same as above.	Same as above
University of Florida Shimberg Center for Housing Studies	Same as above	Same as above
Well Home (a business of Masco Home Services, Inc.)	Same as above. (*Contact arose as a result of networking at the US DOE Building America National Technical Conference in Denver in August 2011 and via subsequent follow up*)	Same as above
Great Reward, LLC	Same as above.	Same as above

	(*Contact arose as a result of networking at the US DOE Building America National Technical Conference in Denver in August 2011 and via subsequent follow up*)	
The Shelton Group, Inc.	Same as above. (*Contact arose as a result of networking at the US DOE Building America National Technical Conference in Denver in August 2011 and via subsequent follow up*)	Same as above
Navigant Consulting, Inc.	Same as above. (*Contact arose as a result of networking at the US DOE Building America National Technical Conference in Denver in August 2011 and via subsequent follow up*)	Same as above
Charlotte Software Systems	UF/PREC is in discussion with this potential collaborator on a variety of potential benefits from utilizing non-linear computational optimization for evaluating various energy efficiency and climate action strategies in the residential sector including the inputs, interactions, and outputs of asset and operational rating systems.	Same as above
Various local and community banks in Florida	UF/PREC has approached multiple financial institutions for potential collaboration on energy efficient financing programs for building retrofits in the residential and light commercial sectors.	N/A
Gainesville-Alachua County Association of Realtors® (GACAR)	Very preliminary discussion has begun on potential future collaboration on integrating residential asset and operational rating information into Multiple Listing Service (MLS) data and/or various local "green" real estate efforts.	N/A
Alachua County Department of Growth Management	Very preliminary discussion has begun on potential future collaboration on integrating residential asset and operational rating information into property appraiser data, building code enforcement data, and/or various local "green" building efforts.	N/A

5.2.2. New Grants/Contracts

Grants / Contracts Awarded					
Title	**Agency**	**Reference Number**	**PI, Co-investigators and collaborators**	**Period of Performance**	**Funding awarded**
Homeowner Energy Interactive Tool Updates	Florida Department of Agriculture and Consumer Services (FDACS) Office of Energy	PO #: S-4200-D1913	PI: Hal Knowles Internal Collaborators: Nick Taylor, Craig Miller, Jennison Kipp, & Pierce Jones External Collaborators: Acceleration.Net	6 weeks (from August 17, 2015 – September, 30 2015)	$8,000
The BEERE Menu: Pre-Packaged Technology Retrofit Options for PACE Financing	US DOE Better Buildings	DE-FOA-0000829 CFDA #: 81.086	PI: EcoCity Partners Co-PI: Hal Knowles, Craig Miller, Nick Taylor Collaborators: Pierce Jones and Jennison Kipp	3 year	$128,420.89 (UF Subcontract portion on a $669,102 overall proposal)
Homeowner Energy Interactive Tool	Florida Department of Agriculture and Consumer Services (FDACS)	PO #: S-4200-A1553	PI: Nick Taylor Co-PI: Hal Knowles	3 months (from March 28, 2013 –	$34,650

	Office of Energy		Internal Collaborators: Craig Miller, Jennison Kipp, & Pierce Jones External Collaborators: Acceleration.Net	June, 30 2013)	

5.2.3. New Proposals

Proposals						
Title	**Agency**	**Reference Number**	**PI, Co-investigators and collaborators**	**Funding requested**	**Project time frame (1 year, 2 years, etc.)**	**Date submitted**
Coming to Cultural Consensus: Residential Utility Bill Transparency, Personal Privacy, and Social Norms	Knight Foundation: Informed & Engaged Communities	News Challenge 2: Data[3]	PI: Hal Knowles Collaborators: Chris McCarty Nick Taylor, Ryan Davis	$160,000	18 months	June 20, 2012
University of Florida Integrative Science for Sustainable Resources (ISSR)	National Institute of Standards and Technology (NIST) Construction Grant Program (NCGP)	2011-NIST-NCGP-01 CFDA #: 11.618	PI: James W. Jones Collaborators / Scientific Team: Wendy D. Graham, Pierce Jones, James C.	$7,228,352 (Federal requested portion on total estimated project cost	5 years (Anticipated from 11/01/2011 to 10/31/2016)	April 4, 2011

[3] http://newschallenge.tumblr.com/

			Oliverio, James Sullivan	of $9,459,340)		
EnergyIT: Home Energy Use Software for Education, Comparison, and Evaluation	U.S. Department of Energy Office of Science	DE-FOA-0000508 CFDA #: 81.049 (FY 2011 SBIR/STTR Phase II Grant Applications)	PI: Pierce Jones Co-PI: Hal Knowles Collaborators: Jennison Kipp & Nick Taylor	$243,008 (UF Subcontract portion on a $992,020 overall proposal)	2 years (Anticipated from July 2011 – June 2013)	April 4, 2011
Gainesville Regional Utilities: On-Bill Energy Efficiency Financing Program Proposal	Gainesville Regional Utilities (Municipally Owned Utility)	N/A (Unsolicited proposal)	PI: Pierce Jones Collaborators: Hal Knowles, Craig Miller, Kathleen Ruppert, Nick Taylor,	$15,000 (UF Subcontract portion on a $80,000 to $135,00 overall proposal)	1 year (Option for annual renewal)	March 25, 2011

6. Patents

Not applicable.

7. Publications

1. **Knowles, III, H.S.** Selected Poster and Presenter – *Home is Where the Heart is: Complexity, Pattern, and Meaning in Short Interval Residential Electric Smart Meter Data*. Graduate Student Research Day – 2015. University of Florida. Gainesville, FL. 2015/10/27.
2. **Knowles, III, H.S.** Invited Presenter – *Home is Where the Heart is: Complexity, Pattern, and Meaning in Short Interval Residential Electric Smart Meter Data*. Water, Wetlands, and Watersheds Seminar – Fall 2015. University of Florida. Gainesville, FL. 2015/09/09.
3. **Knowles, III, H.S.** Selected Poster and Presenter – *Home is Where the Heart is: Complexity, Pattern, and Meaning in Short Interval Residential Electric Smart Meter Data*. Florida Energy

Systems Consortium (FESC) – 2015 Annual Workshop – Track II: Smart Grid and Energy Storage. Orlando, FL. 2015/05/21.

4. **Knowles, III, H.S.** Volunteer Presenter – *Home is Where the Heart is: Complexity, Pattern, and Meaning in Short Interval Residential Electric Smart Meter Data*. School of Natural Resources and Environment (SNRE) Seminar – Spring 2015. University of Florida. Gainesville, FL. 2015/03/10.

8. Attachments

A PDF format slide deck of the full March 10, 2015 SNRE Seminar presentation and a PDF format poster from the May 21, 2015 FESC Workshop are attached herewith for supplementary details to this summary. Additionally, a 50 minute DVD with full video of the March 10, 2015 SNRE Seminar presentation was sent to FESC via UF campus mail the first week of May 2015 in complement to the PDF slide deck.

9. References

1. Zellmer AJ, Allen TFH, Kesseboehmer K. The nature of ecological complexity: A protocol for building the narrative. Ecol Complex [Internet]. 2006 Sep [cited 2012 Mar 30];3(3):171–82. Available from: http://www.sciencedirect.com/science/article/pii/S1476945X0600047X

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APPENDIX E – 2014 FLORIDA UNIVERSITY ENERGY PROJECTS

Biomass

#	Faculty	University	Source/Agency	Project Title
1	Altpeter F	UF	University of Illinois/US DOE	Engineering Hydrocarbon Biosynthesis and Storage Together with Increased Photosynthetic Efficiency Into Saccharinae
2	Boman B J	UF	FDACS	Advancing E Tuber – A Sustainable Feedstock for Biofuels and Biogas on Fallow Florida Citrus Lands
3	Dilorenzo N	UF	FDACS	Integrated Feedstock Development and Management of Oilseed Crops for Drop-In Biolfuels in Florida
4	Dufault N S	UF	FDACS	Integrated Feedstock Development and Management of Oilseed Crops for Drop-In Biolfuels in Florida
5	Evans E A	UF	FDACS	Advancing E Tuber – A Sustainable Feedstock for Biofuels and Biogas on Fallow Florida Citrus Lands
6	Fisher P	UF	USDA	Nutrient, Water and Labor Efficiency in Floriculture Production
7	He Z	UF	St. Lucie County	Evaluate the Impacts of Sediment Storage on Plant Growth in the Detention Area
8	Hodges A W	UF	FDACS	Commercial Production of Terpene Biofuels from Existing Slash Pine Plantations
9	Kirst M	UF	US DOE	A Systems Biology, Whole-Genome Association Analysis of the Molecular Regulation of Biomass
10	Lee W S	UF	BARD (U.s. and Israel Agriculture R&D Fund)	Innovative Yield Mapping System Using Hyperspectral and Thermal Imagine for Precision Tree Crop Management
11	Leon R	UF	FDACS	Integrated Feedstock Development and Management of Oilseed Crops for Drop-In Biofuels in Florida
12	Maupin J A	UF	US DOE	Multifunctional Ubiquitin-Fold Proteins of Archaea
13	Munoz P R	UF	USDA	Improving Breeding Efficiency in Autotetraploids with Genome-Wide Prediction
14	Peter G F	UF	US DOE	Commercial Production of Terpene Biofuels in Pine
15	Santos J E	UF	Alltech Biotechnology Center	Effect of High DHA Algae Supplementation on Fertility of Dairy Cows with an Algae Product Rich in DHA

16	Vermerris S W	UF	USDA	Next Generation Sweet Sorghums – Sustainable Production of Feedstock for Fuels, Chemicals and Value-Added Products
17	Wilkie A C	UF	FDACS	Advancing E Tuber – A Sustainable Feedstock for Biofuels and Biogas on Fallow Florida Citrus Lands
18	Wright D L	UF	FDACS	Integrated Feedstock Development and Management of Oilseed Crops for Drop-In Biofuels in Florida
19	Wu C	UF	Koogler & Associates	Analyzing Elemental Composition of Filter Samples from Biomass Boiler
20	Yang W	FSU	Oak Ridge Associated University	Computational Study of Cellulose Synthase Via Enhanced S…

Carbon Capture

#	Faculty	University	Source/Agency	Project Title
1	Chanton J	FSU	UA	Pathways to Carbon Liberation: A Systems Approach to Understanding Carbon Transformations and Losses from Thawing Permafrost
2	Cooper W	FSU	Georgia Institute of Technology	Soil Carbon Storage and Turnover in a Northern Peatland Forests
3	Jeffrey Cunningham (PI) and Maya Trotz (co-PI)	USF	USGS	Development and Application of New Modeling Capabilities in the Geochemist's Workbench®: Subsurface Sequestration of Supercritical Carbon Dioxide (CO2) in Deep Saline Aquifers.

Catalyst

#	Faculty	University	Source/Agency	Project Title
1	Stiegman A	FSU	University of California (Santa Barbara)	Hierarchical Design of Supported Organometallic Catalyst
2	Zheng J	FSU	General Technical Services	Investigation on the Effects of Porosity and Catalyst ….
3	Weaver J F	UF	US DOE	Growth and Reactivity of Oxide Phases on Crystaline PD and PT Surfaces

Climate

#	Faculty	University	Source/Agency	Project Title
1	Gunzburger M	FSU	US DOE	Predicting Ice Sheet and Climate Evolution at Extreme Scales
2	Jones, W	UCF	NASA	Aquarius Investigation to Quantify Effects of Rainfall on Near-Surface Ocean Salinity Profiles
3	Schuur T	UF	University of Oklahoma/US DOE	From Structure to Functions: Metagenomics-Enabled Predictive Understanding of Soil Microbial Feedbacks to Climate Change

Education

#	Faculty	University	Source/Agency	Project Title
1	Block, David; Harrison, John	UCF	US DOE	Phase 2 of the Southern Region Resource and Training Program as Part of the Southern Alternative Energy Training Network
2	Borkhataria R R	UF	UF Fou	Doris Duke Conservation Scholars Program Partnership Through the University of Florida
3	Carthy R R	UF	UF Fou	Doris Duke Conservation Scholars Program Partnership Through the University of Florida
4	Duffy R	UF	UF Fou	Doris Duke Conservation Scholars Program Partnership Through the University of Florida
5	Georgiopoulos, Michael	UCF	AgileSrc, LLC.	Central Florida – STEM Training Consortium (CF-STEM) Internship Funding
6	Georgiopoulos, Michael	UCF	BBA Aviaton USA Inc.	Central Florida – STEM Training Consortium (CF-STEM) Internship Funding – BBA Aviation, Inc.
7	Georgiopoulos, Michael	UCF	Cubic Simulation Systems, Inc.	Central Florida – STEM Training Consortium (CF-STEM) Internship Funding
8	Georgiopoulos, Michael	UCF	Datanautix, Inc.	Central Florida – STEM Training Consortium (CF-STEM) Internship Funding
9	Georgiopoulos, Michael	UCF	GeoCove, Inc.	Central Florida – STEM Training Consortium (CF-STEM) Internship Funding
10	Georgiopoulos, Michael	UCF	Lockheed Martin Missiles and Fire Control	Central Florida – STEM Training Consortium (CF-STEM) Internship Funding
11	Georgiopoulos, Michael	UCF	Nexgen Global Technologies	Central Florida – STEM Training Consortium (CF-STEM) Internship Funding
12	Georgiopoulos, Michael	UCF	OUC	Central Florida – STEM Training Consortium (CF-STEM) Internship Funding
13	Georgiopoulos, Michael	UCF	US Army PEO STRI	Central Florida – STEM Training Consortium (CF-STEM) Internship Funding
14	Georgiopoulos, Michael	UCF	Aptas Technologies LLC	Central Florida – STEM Training Consortium (CF-STEM) Internship Funding
15	Georgiopoulos, Michael	UCF	Innovative Medical Device Solutions	Central Florida – STEM Training Consortium (CF-STEM) Internship Funding
16	Georgiopoulos, Michael	UCF	Program Works, Inc.	Central Florida – STEM Training Consortium (CF-STEM) Internship Funding
17	Georgiopoulos, Michael	UCF	Stirling Dynamics	Central Florida – STEM Training Consortium (CF-STEM) Internship Funding
18	Georgiopoulos, Michael	UCF	SightPlan Inc.	Central Florida – STEM Training Consortium (CF-STEM) Internship Funding
19	Georgiopoulos, Michael	UCF	NSF	Central Florida – STEM Training Consortium (CF-STEM) Internship Funding
20	Hayes J P	UF	UF Fou	Doris Duke Conservation Scholars Program Partnership Through the University of Florida

21	Kettles, Colleen	UCF	Brevard Workforce Development Board Inc	Education and Training for Clean Energy Cluster Workers

Efficiency

#	Faculty	University	Source/Agency	Project Title
1	Barooah P	UF	NSF	REU Supplement: Career: Distributed Estimation and Control For Energy Efficient Buildings
2	Chasar, David	UCF	Atlantic Housing Partners	Task 1: Energy Analysis and Performance Testing of Multifamily Dwellings
3	Chasar, David	UCF	Atlantic Housing Partners	Task 3: Energy Analysis and Performance Testing of Multifamily Dwellings
4	Fairey, Philip; Sen Sharma, Raju	UCF	Residential Energy Service Network, Inc	Technical Support for Residential Energy Services Network
5	Feiock R	FSU	University of North Texas	RCN-SEES: Predictive Modeling Network for Sustainable Human-Building Eco Systems
6	Gu, Lixing	UCF	Oak Ridge National Laboratory	EnergyPlus Enhancements
7	Gu, Lixing; Raustad, Richard	UCF	NREL	Continuity and Innovation in the Development and Support of Energy Plus
8	Holmes D B	UF	Marion City	Extension Agent – Marion County Community Resource Efficiency Agent
9	Jones P H	UF	FL Housing Finance Corp/US DOE	Utility Energy Data Services for Multifamily Energy Retrofit Program
10	Jung S	FSU	UF	Full Scale Wind Load Testing of Aluminum Screen Enclosures
11	Kettles, Colleen	UCF	Leonardo Technologies, Inc	Space Coast Clean Cities Coalition Support 2012
12	Martin, Eric; Sutherland, Karen; Parker, Danny	UCF	FPL	Phased Deep Retrofits, Phase II
13	Martin, Eric; Withers, Charles; Vieira, Robin; Parker, Danny; McIlvaine, Janet; Fairey, Philip; Chasar, David	UCF	NREL	Building America Partnership for Improved Residential Construction (BA-PIRC) Task Order 5
14	Masters F J	UF	FIU/ Florida Division of Emergency Management	Continuation of Research on the Wind Resistance of Discontinuous Roofing Systems
15	Masters F J	UF	FDBPR	Full Scale Wind Load Testing of Aluminum Screen Enclosures
16	McIlvaine, Janet	UCF	FDBPR	Investigation of Potential Benefits of Revising Exception 1 under Florida Building Code, Energy Conservation

17	Parker, Danny	UCF	University of California/Lawrence Berkeley National Laboratory	Technical Assistance to Lawrence Berkeley National Laboratory with the Home Energy Saver Software
18	Prevatt D O	UF	US DOC	Develop a Technology to Repair Failed Asphalt Shingle Tab Seals to Mitigate Hurricane Wind Damage to Residential
19	Prevatt D O	UF	Metal Construction Association	Evaluation of Wind Uplift Pressures on Air Permeable Discontinuous Metal Roofing Systems
20	Raustad, Richard	UCF	Ranger Energy Saving Technologies, LLC	Initial and Possible Future Testing of a Unitary HVAC System Advanced Control Module
21	Ray A L	UF	Macarthur Foundation, John D & Cath	Multifamily Energy Efficient Consumption, Tenant Stability and Retrofit Effectiveness
22	Roy S	UF	UCF	FHTCC Matching Funds: Plasma Actuated Open Refrigeration Cases: A Basic Study For Better Energy Efficiency
23	Sonne, Jeffrey; Withers, Charles	UCF	FDBPR	A Review of Home Airtightness and Ventilation Approaches for Florida Building Commission Research
24	Swami, Muthusamy; Vieira, Robin	UCF	FDBPR	Development of the Compliance Software Tool Assistance Manual for the 2014 Florida Building Energy Code
25	Withers, Charles	UCF	FDBPR	An Assessment of Energy Efficient Methods of Indoor Humidity Control in Florida Housing for Florida Building Commission Research

Fuel Cell

#	Faculty	University	Source/Agency	Project Title
1	Muradov, Nazim	UCF	Office of Naval Research	An Energy-Dense Al-NaBH4-PEMFC Based Power Generator for Unmanned Undersea Vehicles

Heat Pump

#	Faculty	University	Source/Agency	Project Title
1	Stefanakos, Goswami	USF	AGDF	Field Testing of Gas Heat Pump

LED/OLED

#	Faculty	University	Source/Agency	Project Title
1	Schanze K S	UF	BOE Technology Group CO	High Efficiency OLED Materials and Device Engineering
2	So F	UF	BOE Technology Group CO	High Efficiency OLED Materials and Device Engineering

Marine

#	Faculty	University	Source/Agency	Project Title
1	Fletcher P J	UF	Wildlife Conservation Society	Coordinating Marine-Related Research, Conservation and Extension in Nicaragua and the Wider Carribean
2	Morey S	FSU	Fugro Global Environmental and Ocean Sciences	Hi-Res Environmental Data for Enhanced UDW Operations Safety
3	Qu, Zhihua	UCF	Harris Corporation	Ocean Energy Exploration, Extraction and Monitoring Systems
4	S. H. Skemp	FAU	University of NC	CSI Ocean Energy Gulf Stream Field Observations
5	S.H. Skemp	FAU	US DOE	Southeast National Marine Renewable Energy Center – Advanced Water Power Projects: Modification FY2013 Funding
6	S.H. Skemp & F. Dahlgleish	FAU	US DOE	Unobtrusive Multi-static Serial LiDAR Imager (UMSLI) for Wide-area Surveillance and Identification of Marine Life

Materials

#	Faculty	University	Source/Agency	Project Title
1	Lewis Johnson	FAMU	National Nuclear Security Agency	Consortium for Advanced Chemometrics and in-situ analysis using Laser Ablation Multi Collector Inductively Coupled Mass Spectroscopy (LAMC-ICMS) and/or Laser Induced Breakdown Spectroscopy (LIBS)
2	Lewis Johnson	FAMU	National Nuclear Security Agency/US DOE	Consortium for Research on the Science & Engineering of Signatures (ROSES) .

Nuclear

#	Faculty	University	Source/Agency	Project Title
1	Baciak J E	UF	Battelle Pacific NW Lab	2014 Radiation Detection for Nuclear Security Summer School Support
2	Baciak J E	UF	US DOE	BII3 Gamma-Ray Spectrometers for Reliable Room-Temperature Nuclear Materials Safeguarding
3	Baciak J E	UF	US DOE	University of Florida Nuclear Science and Engineering Fellowship and Scholarship – Christopher Greulich
4	Baciak J E	UF	US DOE	University of Florida Nuclear Science and Engineering Fellowship and Scholarship – Kyle Vaughn

5	Ephrem-Denis Mezonlin	FAMU, Center for Plasma Science & Technology (CePaST)	US DOE	Turbulent Transport Diagnostics for Plasmas
6	Eugenio P	FSU	US DOE	Experimental Hadronic Nuclear Physics
7	Goluoglu S	UF	UT-Battelle	Elements of Nuclear Safeguards, Non-Proliferation and Security
8	Jones, Andrew Jr.	FAMU, Mathematics	USNRC	Preparation for Future Nuclear Scientists and Engineers
9	Jordan K A	UF	US DOE	BII3 Gamma-Ray Spectrometers for Reliable Room-Temperature Nuclear Materials Safeguarding
10	Jordan K A	UF	US DOE	University of Florida Nuclear Science and Engineering Fellowship and Scholarship – Lucas Rolison
11	Manuel M V	UF	Battelle Memorial Institute	Center for Materials Science and Nuclear Fuel
12	Nino J C	UF	US DOE	BII3 Gamma-Ray Spectrometers for Reliable Room-Temperature Nuclear Materials Safeguarding
13	Nino J C	UF	US DOE	University of Florida Nuclear Science and Engineering Fellowship and Scholarship – Paul Johns
14	Phillpot S R	UF	Battelle Memorial Institute	Center for Materials Science of Nuclear Fuel
15	Phillpot S R	UF	University of Illinois/Battelle Memorial Institute	Engineered Zercalor Cladding and Fuel Pellet Modifications for Improved Accident Tolerance of LWR Nuclear Fuel
16	Subash G	UF	Areva Federal Services/US DOE	Holistic Approach to an Enhanced Accident Tolerant Fuel System
17	Tulenko J S	UF	Battelle Memorial Institute	Development of Innovative Accident Tolerant High Thermal Conductivity UO2-Diamond Composite Fuel Pellets
18	Tulenko J S	UF	Areva Federal Services/US DOE	Holistic Approach to an Enhanced Accident Tolerant Fuel System
19	Weatherford, Charles	FAMU	Tuskegee University/National Nuclear Security Agency	Experimental & Computational Studies on High Temperature Plasmas
20	Weatherford, Charles	FAMU	National Nuclear Security Agency/US DOE	Consortium for Materials and Energy Studies (CMAES)
21	Yang Y	UF	University of Illinois / Battelle Memorial Institute	Engineered Zircaloy Cladding and Fuel Pellet Modifications for Improved Accident Tolerance of LWR Nuclear Fuel

22	Yang Y	UF	University of Chicago/ US DOE	Institu HighEnergy X-Ray Characterization For Microstructure, Deformation and Damage Evolution in Nuclear Reactor

Other

#	Faculty	University	Source/Agency	Project Title
1	Abdolvand, Reza	UCF	NSF	GOALI: Lateral-Mode MEMS Filter Arrays on Ultrananocrystalline Diamond for Multi-Band Communication
2	Adams T	FSU	Fermi National Accelerator Lab	Activities Related To Forward Calorimetry R&D
3	Albrecht-Schmitt T	FSU	US DOE	Differentiating between Lanthanides and Actinides
4	Albrecht-Schmitt T	FSU	University of Notre Dame	TAS Recovery Act: Material Science of Actinides-EFRC
5	Alvi F	FSU	Air Force Office of Scientific Research	A Comprehensive Study of 3-D Shock/Turbulent Boundary Layer Interaction Physics
6	Alvi F	FSU	UF	PIRE: Collaborations with Japan and France on Complex and Multiphase Fluid and Science Technologies
7	Askew A	FSU	Universities Research Associate	Search for Supersymmetry in Events with Photons
8	Atia, George	UCF	University of Rochester	Exploiting Multidimensional Classical Optical Entanglement for Enhanced Spatial Scene Recognition
9	Balachandar S	UF	Los Alamos National Security	Coupling of the Particle Transport Model to the Turbulence Model
10	Balachandar S	UF	US DOE	PSAAP: Center for Compressible Multiphase Turbulence (CCMT)
11	Cattafesta L	FSU	NASA	Aeroacoustic Measurements of a Leading Edge-Slat
12	Cattafesta L	FSU	NSF	I/UCRC Planning Grant: Applications in Flow Control
13	Cattafesta L	FSU	ONR	A Novel Method to Predict Circulation Noise Control
14	Cattafesta L	FSU	UF	ONR Vortex 87790 – An Experimental Investigation of Wing
15	Chen Y	UF	US DOE	Prediction of Thermal Transport Properties of Materials with Microstructural Complexity
16	Cheng H P	UF	US DOE	A Computational Approach to Complex Junctions and Interfaces
17	Cheng H P	UF	NSF	Understanding and Reducing Thermal Noise via Atomistic Simulations
18	Chernatynskiy A	UF	Battelle Pacific NW Lab	Micro/Nano Scale AFM-Based Thermal Conductivity Measurement and Atomistic Modeling for Oxide Fuel
19	Child B	UF	Nature Conservancy	UF-TNC Partnership to Develop Transidsiciplinary Research in the Nature Conservancy's African Conservation Programs

20	Field R D	UF	US DOE	Collider Physics at the University of Florida
21	Furic I K	UF	Fermilab	CMS Phase 2 Upgrade R&D Subsystem-GEM Detector R&D/MUON TRIGGER R&D
22	George A D	UF	US DOE	PSAAP: Center for Compressible Multiphase Turbulence (CCMT)
23	Georgiopoulos, Michael	UCF	NSF	I3: The UCF Community Embraces the Knowledge-Based Economy
24	Gong, Xun	UCF	Defense Advanced Research Projects Agency	Customizable Antenna Array Using Pixelated and Reconfigurable Slot-Ring Antennas
25	Gonzalez A H	UF	Caltech/NASA	Constraining Dark Energy and Modified Gravity with Euclid
26	Guan Y	UF	Sandia National Laboratories	Computational Studies for the Unit Commitment Problem Under Uncertainty in the Current Deregulated Energy Market Environment
27	Guan Y	UF	University of Chicago/US DOE	Integrating FTR with Power System Operations
28	Gugel K S	UF	Verifone	IPPD 2013-2014: Distributed Multimedia Infrastructure for Fuel Dispensing Operations
29	Gunzburger M	FSU	US DOE	DIAMOND: An Integrated Multifaceted Approach to Mathematics at the Interfaces of Data, Models, and Decisions
30	Gunzburger M	FSU	US DOE	EQUINOX: Environment for Quantifying Uncertainty: Integrated and Optimized at the Extreme Scale
31	Haftka R T	UF	US DOE	PSAAP: Center for Compressible Multiphase Turbulence (CCMT)
32	Hall C D	UF	US NAVY	Novel Energy-Rich Linear Triazenes, Nitrogen Ylids and Heterocyclic N-Oxides
33	Hirschfeld P J	UF	US DOE	Theory of Novel Superconductors
34	Jones J L	UF	NSF	Participant Support: IRES: Australian International Research Experience for Students: Materials for Energy Technologies
35	Jones, W	UCF	NASA Shared Services Center	GOLD SALMON project (Imaging Earth's Thermosphere and Ionosphere from geostationery orbit)
36	Jones, W	UCF	NASA Shared Services Center	On Orbit Inter-Satellite Radiometric Calibration
37	Katritzky A R	UF	US NAVY	Novel Energy-Rich Linear Triazenes, Nitrogen Ylids and Heterocyclic N-Oxides
38	Kettles, Colleen	UCF	US DOE	Advancing Alternative Fuel Markets in Florida
39	Kim N H	UF	US DOE	PSAAP: Center for Compressible Multiphase Turbulence (CCMT)
40	Kobziar L N	UF	US DOI	Food, Fuel and Fire: Assessing the Effects of Fuel Treatments on Wildlife Habitat Quality in Longleaf Pine
41	Kumar R	FSU	M4 Engineering	Evaluation of Unsteady Loading on Store Trajectories

42	Kumar R	FSU	M4 Engineering	Wind Tunnel Balance Correction for Structural Motion Effects
43	Kumar R	FSU	Northrop Grumman Corporation	Flowfield Characteristics of Axisymmetric and Non-Axixym
44	Ladd A J	UF	US DOE	Reaction-Infiltration Instabilities in Fractured and Porous Rocks
45	Lampropoulos, Christos	UNF	Research Corporation for Science Advancement	Target Synthesis of Hybrid Nanomaterials From Single-Molecule Magnets
46	Larbalestier D	FSU	US DOE	NB3SN Superconductors for the LHC and for Accelerators B
47	Larbalestier D	FSU	US DOE	The Underlying Science of High Critical Current Density
48	Lee P	FSU	Supramagnetics, Inc	A New Nb3Sn Process with a Novel Artificial Pinning Center for High-Energy Physics and High Magnetic Field Applications
49	Lee P	FSU	US DOE	The Cost of Grain Boundaries on the Performance of Superconductors
50	Liou, Juin	UCF	Analog Devices	Failure Criteria Metric under ESD Stress Conditions
51	Malocha, Donald	UCF	NASA Langley Research Center	RF: TT NASA Langley Wafer Fabrication 6 Designs
52	Malocha, Donald	UCF	QinetiQ North America	TTO: Malocha Auxiliary Balance Account
53	Manuel M V	UF	Sandia National Libraries	Effects of Alloying Additions to the Structure and Properties of Magnesium Thin Films – Fellowship for Ryan Hooper
54	Matchev K T	UF	US DOE	Task T: Elementary Particle Theory and Phenomenology at the University of Florida
55	McGinnis R	FSU	Naval Sea Systems Command	Research and Development of Next Generation Naval Integrated Power Systems
56	Milligan J	FSU	RTI International	Science, Technology, Research and Innovation Development
57	Mitselmakher G	UF	FERMILAB	LPC Fellowships in Physics for Souvik Das
58	Mitselmakher G	UF	US DOE	Task P: Research in High Energy Experimental Physics Using the CMS Detector at the Large Hadron Collider, Cern
59	Newman M A	UF	SM Stoller Corporation	Baffled Multi-Level Samplers (BMLS)
60	Nuszkowski, John	UNF	Life Cycle Engineering, Inc	Small Scale Engine Performance Screening for Alternative Navy Fuels
61	Oates W	FSU	Air Force Office of Scientific Research	Modeling and Experimental Characterization of Novel Photomechanical Fibers
62	Oates W	FSU	Florida A&M University	Simulation of Fluid-Structure Interaction for High-Reynolds
63	Pamidi S	FSU	Tai Yang Research Corp	hSTTR: Fabrication of Higher Temperature Semiconductors
64	Phillpot S R	UF	Los Alamos National Security	Effect of Strain on Defect Migration in Fluorite Structured Oxides

65	Phillpot S R	UF	US DOE	Innovative Coating of Nanostructured Vanadium Carbide on the F/M Cladding Inner Surf Mitigating the Fuel
66	Piekarewicz J	FSU	US DOE	From Quarks to the Cosmos
67	Plewa T	FSU	US DOE	Diverging Supernova Explosion Experiments on NIF
68	Prosper H	FSU	US DOE	High Energy Research at Florida State University
69	Prosper H	FSU	Universities Research Association	Electrons in Jets and Searching Beyond the Lamppost
70	Qu, Zhihua	UCF	Coleman Aerospace	Novel Guidance and Control Algorithms for Missile Defense Systems
71	Rahnavard, Nazanin	UCF	NSF	CIF: Small: Collaborative Research: Cooperative Sensing and Communications for Cognitive Radio Networks
72	Ramachandran, Bhuvane	UWF	FL Space Grant Consortium	Team ARGONAUCKET: NASA Training Grant Hybrid Rocket Competition
73	Ranka S	UF	US DOE	PSAAP: Center for Compressible Multiphase Turbulence (CCMT)
74	Ray H	UF	US DOE	Neurino Cross Sections: Foundations of the Future
75	Ren F	UF	Agnitron Technology/ US DOE	Manufacturing Improvements of AIN for Wide Bandgap Semiconductor Devices – Phase I
76	Roberts W	FSU	US DOE	Research in Hadron Physics
77	Schert J D	UF	FL DOT	Development of Standard Operating Procedure for Analysis of Ammonia Concentrations in Coal Fly Ash
78	Schlottmann P	FSU	US DOE	Strongly Correlated Electron Systems
79	Seyedi-Esfahani, Alireza	UCF	Griffiss Institute, Inc.	Inference in Complex Networks of Dynamical Systems
80	Shatruk M	FSU	UT-Battelle LLC	Computational/Combinatorial Discovery of New Intermetall
81	Sheplak M	UF	Caltech/US Airforce	Wall Turbulence with Designer Properties Identification, Characterization and Manipulation of Energy Pathways
82	Shih C	FSU	Florida A&M University	High Temperature Supersonic Jet Noise Fundamental Studies
83	Shih C	FSU	National Park Service	Cone and Friction Cone Penetrometer Applications to Arch
84	Shih C	FSU	University of Michigan Ann Arbor	Noise and Thermal Mitigation of Naval Systems
85	Siegrist T	FSU	US DOE	Discovery and Crystal Growth of New Oxide Phases from Metal Fluxes
86	Siegrist T	FSU	UT-Battelle LLC	Go Program: Jifeng Sun – Computation of Electronic Band
87	Singh R K	UF	SINMAT	FHTCC: Novel Polishing to Fabricate Ultra Low Thickness Variation Diamond Substrates For Next Generation Beam

88	Smirnov D	FSU	US DOE	Infrared Optical Study of Graphene in High Magnetic Fields
89	Soltis D E	UF	US DOC	PD-14-02 Conservation Genetics of Red Mangroves in Florida
90	Stefanakos, Goswami	USF	FPL	Performance Evaluation Energy Saving Potential of VaporGenics Organic Rankine Cycle Air-Conditioning Unit
91	Steurer M	FSU	Alliance for Sustainable Energy, LLC	NREL PHIL Anti-Islanding Testing and Demonstration
92	Stewart G R	UF	US DOE	Understanding Iron Superconductors/Focus on Nodal Behavior
93	Taira K	FSU	Air Force Office of Scientific Research	Understanding the Fundamental Roles of Momentum and Vorticity Injections in Flow Control
94	Taira K	FSU	US ARO	Network-Theoretic Modeling of Fluid Flow
95	Taira K	FSU	US ARO	Turbulent Flow Modification with Thermoacoustic Waves for Separation Control
96	Taira K	FSU	UF	Three Dimensional Control of High Speed Cavity Flows
97	Tanner D B	UF	US DOE	Search for Axionic Dark Matter
98	Tanner D B	UF	US DOE	The Generation 2 Axion Dark-Matter Experiment (GEN 2 ADMX)
99	Telotte J	FSU	NSF	Collaborative Project: Energy Sustainability Remote Laboratory
100	Townsend T G	UF	FL DOT	Development of Standard Operating Procedure for Analysis of Ammonia Concentrations in Coal Fly Ash
101	Tozer D	FSU	US DOE	Electron Interactions in Actidnides and Related Systems
102	Trickey S B	UF	US DOE	Orbital-Free Quantum Simulation Methods for Application to Warm Dense Matter
103	Uzun A	FSU	National Institute of Aerospace	Direct Numerical Simulation of Three-Dimensional Boundary Layer Receptivity to Spanwise Periodic Roughness Elements
104	Van Sciver S	FSU	US DOE	Liquid Helium Fluid Dynamics Studies
105	Volya A	FSU	US DOE	Atomic Nucleus: A Finite Open Quantum Many-Body System
106	Wahl H	FSU	University of Notre Dame	Quarknet
107	Walsh R	FSU	UT-Battelle LLC	One Piece Tie Plate Specimen Testing
108	Wang, Jun	UCF	NSF	CAREER: Data-Intensive HPC Analytics: A systems approach through extended interfaces, data restructuring and data-centric scheduling
109	Watling J I	UF	US DOI	Setting Conservation Targets for the Peninsular Florida Landscape Conservation Cooperative
110	Wiedenhoever I.L.	FSU	US DOE	Spectroscopy of Resonances in the Astrophysical rp-Process Pathway

111	Wu, Xinzhang (Thomas)	UCF	Rini Technologies, Inc.	Thermal Management of Electrical Actuation via Enhanced Air Circulation
112	Wu, Xinzhang (Thomas)	UCF	ANSYS, Inc.	Development of Electric Machine Advanced Modeling Techniques
113	Wu, Xinzhang (Thomas)	UCF	Calnetix, Incorporated	Three Dimensional FEA Modeling and Permanent Magnet Motor
114	Yang Y	UF	US DOE	Innovative Coating of Nanostructured Vanadium Carbide on the F/M Cladding Inner Surf Mitigating the Fuel
115	Yang Y	UF	Battelle	Micro/Nano Scale AFM-Based Thermal Conductivity Measurement and Atomistic Modeling for Oxide Fuel
116	Yang Y	UF	University of Chicago/ US DOE	Microstructural Analysis of Stainless Steels and Nickel Alloys for LWR Applications
117	Ye M	FSU	US DOE	Computational Bayesian Framework for Quantification and Reduction of Predictive Uncertainty in Groundwater Reactive Transport Modeling

Sensors

#	Faculty	University	Source/Agency	Project Title
1	Malocha, Donald	UCF	Albido Corporation	Passive Wireless Sensor System for Structural Health Monitoring
2	Malocha, Donald	UCF	NASA Langley Research Center	RF – TT Commercialization “Saw Temperature Sensor System”
3	Malocha, Donald	UCF	MNEMONICS, Inc.	Wireless SAW Strain Gauge and Integrated Interrogator Design
4	Oates W	FSU	UF	A01 3 High-Temperature Sapphire Pressure Sensors for Har
5	Rahnavard, Nazanin	UCF	NSF	CAREER: A Generalized Compressive Sensing Approach to Data Acquisition and Ad-Hoc Sensor Networking
6	Sheplak M	UF	US DOE	High-Temperature Sapphire Pressure Sensors for Harsh Environments
7	Yuan, Jiann-Shiun; Lin, Mingjie; Gong, Xun; DeMara, Ronald; Atia, George; Abdolvand, Reza	UCF	NSF	I/UCRC Multi-functional Integrated System Technology (MIST)

Smart Grid

#	Faculty	University	Source/Agency	Project Title
1	Click, David; Reedy, Robert; Moaveni, Houtan	UCF	FSU	SUNGRIN Simulation-Assisted Understanding of the High-Penetration PV Effects and Requirements

2	Colon, Carlos	UCF	US DOI/National Park Service	Technical Assistance for the Electric Load Survey and Battery Energy Storage Recommendation at the Dry Tortugas Garden Key National Park
3	Edrington C	FSU	NCSU	NSF Engineering Research Center for Future Renewable Electric Energy Delivery
4	Edrington C	FSU	University of Texas at Arlington	Organic Distributed Decision-Making for Heterogeneous Energy Systems
5	Faruque M.O.	FSU	UCF	Foundations for Engineering Education for Distributed Energy Resources (FEEDER)
6	Meyn S	UF	UCF/US DOE	FEEDER: Foundations for Engineering Education for Distributed Energy Resources
7	Moaveni, Houtan; Click, David	UCF	Tampa Electric Company	TECO Energy Project
8	Pearton S J	UF	Agnitron Technology	Manufacturing Improvements of AIN For Wide Bandgap Semiconductor Power Devices – Phase I
9	Qu, Zhihua	UCF	Leidos	Electric Power Markets, Case Studies, and Energy Management System
10	Qu, Zhihua; Vosoughi, Azadeh; Simaan, Marwan; Seyedi-Esfahani, Alireza; Lotfifard, Saeed	UCF	US DOE	Foundations for Engineering Education for Distributed Energy Resources (FEEDER)
11	Reedy, Robert; Click, David	UCF	US DOE	Foundations for Engineering Education for Distributed Energy Resources (FEEDER)

Solar

#	Faculty	University	Source/Agency	Project Title
1	Anderson T J	UF	Midwest Research Inst/US DOE	Enabling the CIGS Thin-Film PV Technology to Meet the DOE GOAL of $0.50/W Module Price
2	Barkaszi, Stephen	UCF	NREL	High Voltage Test Bed for PV Modules
3	Click, David; Moaveni, Houtan	UCF	FL DOT	Solar Power at the Turkey Lake Service Plaza: A Best Practices Guide for Governmental Agencies Interested in Solar Power Projects
4	Click, David; Moaveni, Houtan; Kettles, Colleen	UCF	City of Orlando	City of Orlando: 2MW PV Project at Wastewater Facility
5	Click, David; Reedy, Robert	UCF	OUC	Solar Technical Services
6	Click, David; Schleith, Mrs. Susan; Moaveni, Houtan; Kettles, Colleen	UCF	Duke Energy Florida, Inc.	SunSmart Schools E-Shelter Plus-Up (Utility Program) AKA SunSense Plus UP
7	Click, David; Schleith, Susan	UCF	Duke Energy Florida, Inc.	Duke Energy SunSense Schools – 2014

8	Dhere, Neelkanth	UCF	NREL	Comparison the modes and mechanisms of degradation of experimental c-Si PV modules with various encapsulants
9	Dhere, Neelkanth	UCF	Colorado School of Mines	Solar Energy Research Institute for India and the United States (SERIIUS)/ Study of PV module Reliability and Durability in the Hot and Humid Climate
10	Ehsani R	UF	Citrust Research and Development Foundation	In Field Solar Heat Treatment of HLB-Infected Orange Trees for Inoculum Reduction
11	Hahn D W	UF	US DOE	Solar Thermochemical Fuel Production via A Novel Low Pressure, Magnetically Stabilized, Non-Volatile Iron Oxide Looping
12	Kettles, Colleen; Click, David; Barkaszi, Stephen	UCF	Broward County	Go SOLAR Florida: SunShot Challenge II
13	Meeker R	FSU	US DOE	The Sunshine State Solar Grid Initiative
14	Mei R	UF	US DOE	Solar Thermochemical Fuel Production via A Novel Low Pressure, Magnetically Stabilized, Non-Volatile Iron Oxide Looping
15	Schleith, Susan	UCF	FPL	RF: FPL SunSmart Schools DAS program
16	Schoenfeld, Winston	UCF	HybridaSol, LLC	Applied Research in Thermoelectric Materials Processing and Hybrid Thermoelectric-Photovoltaic Devices
17	Shields, Sherri	UCF	Sherwood Associates, Inc.	Solar ABCs Website Maintenance
18	Shih C	FSU	UCF	Direct Drive Solar-Powered Arcjet Thruster
19	So F	UF	US NAVY	Ambient Processing of Polymer Solar Cells
20	So F	UF	Nanoholdings	Infrared Sensors and Broadband Absorbing Solar Cells
21	Stanton C J	UF	Washington University/NSF	Development of Laser-Enhanced NMR For Spectroscopy of Photovoltaic Materials
22	Stefanakos Goswami	USF	Colorado School of Mines	Sustainable Phovoltaics and Subcontract Coordination (SERIIUS) CSM
23	Stefanakos Goswami	USF	NSF	EAGER: Development of a Rectenna for Energy Harvesting and Detection Applications
24	Walters B S	UF	US DOE	Solar Living House
25	Wei W	UF	NSF	CAREER: The Rational of Plasmonic Photocatalysts for Efficient Solar Energy Conversion
26	Wu, Xinzhang (Thomas)	UCF	Applied Power Electronics Corp	Integrated Inductor Design for High-Efficiency, High-Density Soft-Switching Multi-Port Photovoltaic Power Manager for SBIR OSD Phase I Project O133-EP2-2210

Storage

#	Faculty	University	Source/Agency	Project Title
1	Abdolvand, Reza	UF	NSF	EAGER: Investigation and Optimization of Thermoelectric Properties of Highly-Doped Polysilicon Nanowires
2	Goswami and Stefanakos	USF	US DOE – ARPA-E	Development of a Low Cost Thermal Energy Storage System Using Phase Change Materials with Enhanced Radiation Heat Transfer
3	Goswami and Stefanakos	USF	Keilir Energy Center / Univ. of Iceland	PCM Thermal Energy Storage and Transport System (TEST) For the Utilization of Geothermal Heat and other Heat Source
4	Hahn D W	UF	US DOE	Carbon Dioxide Shuttling Thermochemical Storage Using Strontium Carbonate
5	Li T	UF	NSF	CSR: Small Leveraging Distributed Generation and Adaptive Energy Storage Management for Efficient and Scale-Out Renewable
6	Mei R	UF	US DOE	Carbon Dioxide Shuttling Thermochemical Storage Using Strontium Carbonate
7	Muradov, Nazim	UCF	Texas A&M Engineering Experiment Station	Solar Hybrid Hydrogen Production Cycle with In-situ Thermal Energy Storage
8	Stefanakos	USF	NSRC	Microencapsulated Phase Change Materials
9	Zheng J	FSU	Battelle Memorial Institute	Investigation of Pre-Lithiated Anodes for Li-Ion Batteries
10	Zheng J	FSU	FSU Foundation	Development of High Energy Li Capacitors
11	Zheng J	FSU	General Capacitor	Development and Characterization of Li-ion Capacitor ….

Transportation

#	Faculty	University	Source/Agency	Project Title
1	Block, David	UCF	US DOT	Electric Vehicle Transportation Center (EVTC)
2	Guan Y	UF	NSF	Plug-in Hybrid Electric Vehicles and Electricity Markets
3	Liou, Juin	UCF	Allegro MicroSystems, LLC	Design, Characterization, and Optimization of Electrostatic Discharge (ESD) Power Clamps for Automotive Electronics
4	Qu, Zhihua	UCF	US DOT	Electric Vehicle Transportation Center (EVTC)
5	Washburn S S	UF	US DOT	On-Board Diagnostics Integration Into Traffic Microsimulation for Vehicle-Specific Fuel Use and Emissions

Waste to Energy

#	Faculty	University	Source/Agency	Project Title

1	Joseph, B.	USF	NCIIA- E-Team Grant	Conversion of Landfill Gases to Liquid fuels
2	Kuhn & Joseph	USF	NCIIA (now Venture Well)	NCIIA Trash 2 Cash-Energy Phase II Proposal

Water

#	Faculty	University	Source/Agency	Project Title
1	Lamm A J	UF	USDA	Smart Phone Apps: Scientific Validation Quantification of Water Conservation
2	Migliaccio K W	UF	USDA	Smart Phone Apps: Scientific Validation Quantification of Water Conservation
3	Migliaccio K W	UF	USDA	Smart Phone Apps: Scientific Validation Quantification of Water Conservation
4	Rowland D L	UF	USDA	Smart Phone Apps: Scientific Validation Quantification of Water Conservation

Wind

#	Faculty	University	Source/Agency	Project Title
1	Jones, W	UCF	NASA Shared Services Center	Improved Active/Passive Ocean Vector Wind Retrievals
2	Jones, W	UCF	NASA Marshall Space Flight Center	Observations of Ocean Surface Wind Speed and Rain Rate with the Hurricane Imaging Radiometer (HIRAD)