Florida State University

Biofuels Through Thermochemical Processes: Approach to Produce Bio-jet Fuel

PI: A. Krothapalli

Description: 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.

Budget: $229,572
Universities: FSU

Executive Summary

Through molecular manipulations, the inherent chemistry of the proposed approach allows the production of "designer biofuels" and offers a means to tailor product properties through saturation of double bonds to give better shelf life, cleaving long chain hydrocarbons to produce the jet cut, controlling aromatics content for better combustion characteristics and isomerization to achieve better performance

We are now hydro-processing the bio-oils. This particular step is being carried out by our industrial partner Energia Technologies Inc., of Oakland, California. Energia Technologies is currently building high pressure and temperature bench scale unit capable of independently testing bio conversion unit. This work is being carried out under an Office of Naval Research STTR phase I program where FSU is a sub-contractor to this effort.

Funds Leveraged/New Partnerships:
Energia Technologies Inc. in Oakland California

This project has been completed.

Florida State University

Constructual Optimization of Solar Photo-Bioreactors for Algae Growth

PI: Juan Ordonez
Students: Quinn Straub (MS), Tom Tracy (MS)

Description: This planning grant has allowed us to enhance our laboratory capabilities and personnel qualifications to support competitive proposals in the area of bio-fuels. By the end of this one-year effort, we have a complete design of a small-scale photo-bioreactor for algae growth and 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.

Budget: $15,000
Universities: FSU
External Collaborators: Federal University of Parana, Brazil

Executive Summary

This project is complete. Graduate students Straub and Tracy attended a 2-day seminar hosted by the University of Texas at Austin. The seminar exposed the students to fundamentals of the biological interactions of micro-algae, culturing techniques, culture maintenance, as well as, proper use of lab equipment. They also toured a culture collection that is one of the best in the world with over 3,000 species of algae.

This project has been completed.

Florida Energy Systems Consortium

Florida State University

Development of a Renewable Energy Research Web Portal

PI: Charles R. McClure **Co-PIs**: Ian Douglas, Chris Hinnant

Students: Bradley Wade Bishop (MA Information Institute), Nicole D. Alemanne (MS Information Institute), Karen Doster, MS, Jiangna Han (MS Learning Systems Institute), Mike Falcon (B.A Information Institute)

Description: This one-year project will identify, organize, and make 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 is 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 will be an operational web portal that identifies, organizes, and provides access to a range of FESC and research related to renewable and alternative energy information. A second product will be 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 will position FSU to seek additional external funding related to interactive databases and web portals. 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: $194,543
Universities: FSU

Executive Summary

The project team designed the study to include five tasks: 1) gather background information pertaining to renewable energy research, 2) conduct a needs assessment, 3) design and develop the renewable energy web portal, 4) evaluate the renewable energy web portal, and 5) disseminate and publicize the renewable energy web portal. In the first six months of the project the team completed the first task and began to work on tasks 2 and 3. Tasks 2 and 3 were completed and tasks 4 and 5 initiated by the project team during the next six-month period as the portal itself was developed and improved. The project team continued to refine the portal, evaluate its usage, and disseminate and publicize the portal to the renewable energy research community. Furthermore, the project team also attempted to explore additional means of pursuing funding opportunities from several research foundations, as well as government agencies.

During the project period, the project team developed, launched, evaluated, and improved the renewable energy research web portal. Furthermore, the project team publicized the portal and its features to the broader renewable energy community. During the no-cost extensions, the project team also pursued additional sources of external funding from private foundations and government agencies. The project team will continue to pursue funding as future opportunities arise. The portal is currently available to the renewable energy research community and the public at the following URL: http://energyportal.cci.fsu.edu/.

This project has been completed.

FESC
Florida Energy Systems Consortium

Florida State University

Energy and Efficiency Video Public Service Announcements

PI: Andy Opel **Co-PIs:** Phil Steinberg, Leslie France-Patterson, Laura Arpan, Ian Weir

Description: This interdisciplinary team will produce 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
Universities: FSU

Executive Summary

Beginning in January 2009, our five member faculty team began meeting, with the addition of two quarter time doctoral graduate students funded by the grant; Jia Lu from Communication and Adam Keul from Geography. Laura Arpan and Jia Lu assembled an up to date literature review of research in the area of communication campaigns and environmental communication/persuasion. A summary of this work was presented to the group in late February 2009, with the goal of shaping the message strategy that would be emphasized in the PSAs.

Arpan and Lu then went on to develop a survey questionnaire to be administered to a random sample of Florida residents. This survey data will serve as baseline data as we begin message testing specific PSAs. Data from the survey was collected in May 2009 and analysis of that data is on-going. In addition, Arpan established partnerships with the Yale Project on Climate Change and the Center for Climate Change Communication at George Mason University. These partnerships include data sharing and survey question collaboration.

Based on the communication research aggregated by Arpan and Lu, Opel, Steinberg, France-Patterson, Weir, and Keul developed PSA ideas resulting in over 20 potential PSA videos. This list was narrowed down to the top eight concepts through consultation with Arpan and Lu. Production plans were developed for each concept, including locations, costumes, cast, script, storyboards and props. Production plans included variations within each PSA that will allow for message testing in the fall of 2009. The messages were developed and tested on different demographic groups for preference testing.

This project has been completed.

FESC
Florida Energy Systems Consortium

Florida State University

Energy Sustainable Florida Communities

PI: Richard Fieock**, Co-PIs:** Ivonne Audirac, Keith Ihlanfeldt
Student: Christy Smith, PhD in Public Administration

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
Universities: FSU

Executive Summary

We sent out monthly activity updates to our members, held a regional workshop in Palm Beach County, and co-hosted with FCCMA an Energy Efficiency and Sustainability symposium in Tallahassee. We held our second regional workshop scheduled for the Jacksonville area on March 15, 2011, and have tentative plans to hold workshops in central Florida as well as the western Panhandle area. In addition to our outreach efforts related to local governments in the state via the workshops and symposium, we are also networking with sustainability directors at Arizona State, Washington State, Notre Dame, and Michigan to share best practices. Christy Smith organized our first conference call and Julia Parzen of the network coordinator for the Urban Sustainability Directors Network, a national sustainability network, joined the call. We have also developed relationships with the State Energy Office, Johnson Controls, Inc., GE, and Metal Essence, the only LED manufacturing company in the state. We are hoping to continue to develop these relationships to facilitate our outreach efforts as well as to jump-start the bulk purchasing aspect of our mission. We have also developed a website that provides resources to local governments looking for information on using the state term contract, performance contracts, and the EECBG program in general.

This project has been completed.

FESC
Florida Energy Systems Consortium

Florida State University

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
Students: Andres Lastra, M.S.; F. Rios, M.S.; Gustavo Munoz, B.S.; Libo Cui, Ph.D.

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: $64,738
Universities: FSU

Executive Summary

A literature review of environmental impacts of energy production systems is complete. We conducted an extensive literature reviews on how biofuel production systems, with a focus on cellulosic ethanol, affect our environmental resources and quality. Approximately 400 journal papers, reports, and permit applications were reviewed for this task to date. This includes impacts on the potential contamination of water, soil, and air, demands on water resources, ecosystem and human health, and emissions of greenhouse gases. We have found that the local impacts and downstream issues such as effluent and by-products from biorefineries have largely been overlooked in the literature. However, these issues are relevant and are significant when siting and permitting these facilities. Two manuscripts to peer-reviewed journals were submitted:

Science, December 2009, declined; and Environmental Science & Technology, August 2010, published 2011. A spread-sheet based evaluation and decision support tool was developed. Also, a GIS-tool used to evaluate the impact of nutrients from point sources was developed. This helps in assessing the environmental impacts of feedstock growth and biorefinery processes from biofuels.

This project has been completed.

Florida State University

Establishment of the Center for Marine Bioenergy Research: Systems Approach to BioEnergy Research (SABER)

PI: Joel Kostka **Co-PIs**: William Cooper, Ivonne Audirac, Amy Chan-Hilton,Ellen Granger
Students: Claire Smith (Ph.D.), Kristina Welch (M.S.)

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
Universities: FSU
External Collaborators: City of Tallahassee

Executive Summary

Joel Kostka directs the Systems Approach to Bio-Energy Research (SABER) facility until August, 2011, when he leaves for Georgia Tech. Afterward, Jeff Chanton has agreed to become director and lead the program into the future. Bill Cooper of the Chemistry department and Mike Watts of the FAMU-FSU College of Engineering both serve as SABER Co-PIs and they will continue to support the program by directing students. Timeline and Operation of Facility: Maintenance and day-to-day operations of the facility will be carried out by graduate students, Claire Smith and Kristina Welch. Both of these students will pursue the M.S. degree in the Earth, Ocean and Atmospheric Sciences (EAOS) department. The students plan to finish their degrees in 2012. Both student theses will be directed by Professor Chanton. Kostka will co-direct Claire's thesis research as a courtesy faculty member of EOAS, while Mike Wetz will continue to codirect Kristina's thesis project. Kostka will also serve as a member of Kristina's thesis committee. Bill Cooper has participated in SABER as a coPI since its inception. He has agreed to help run the algal cultivation facility and will serve on the thesis committees of both Claire and Kristina. This arrangement should work quite well.

This project has been completed.

Florida Energy Systems Consortium

Florida State University

Experimental Investigation of Economic Incentives of Policies, Institutions, and R&D in Environmental Conservation

PI: Svetlana Pevnitskaya **Co-PI:** Dmitry Ryvkin
Students: Matt Cutillo

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 employ methods of experimental economics to find and explore such deviations and their causes, and use the findings to modify theory and design better policies and institutions. In this project, we construct 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.

Budget: $43,168.00
Universities: FSU

Executive Summary

This project is the first, to the best of our knowledge, laboratory experimental study of the effects of environmental context, technological heterogeneity, and investment in clean technologies in an environment with a dynamic public bad. It also provides interesting and at times unexpected insights that have direct implications for policy or at least require a more detailed investigation. Specifically, we find that

- Environmental context and "green" framing, even if purely symbolic, have consequences for economic decisions.
- Under relatively low cost of pollution heterogeneous countries are less likely to achieve sustainability without external enforcement than under more severe costs of pollution and climate change.
- Common access to clean technology leads to higher investment in clean technology, lower levels of pollution and dominating payoffs. The results suggest that policies promoting research and development collaboration and technology sharing in combating environmental damage and climate change are effective.

This project has been completed.

FESC
Florida Energy Systems Consortium

Florida State University

Innovative Proton Conducting Membranes for Fuel Cell Applications

PI: Ongi Englander **Co-PIs:** Anant Paravastu, Subramanian Ramakrishnan

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: $30K
Universities: FSU

Executive Summary

Project Impact and Conclusions: *Synthesis and Characterization of Latex Composite Membranes using monodisperse particles:* Particles of 200 nm, 650 nm and 900 nm were successfully synthesized using an emulsion polymerization technique. Membranes were then fabricated by depositing these particles on commercial supports and by heat stabilizing them.

Incorporation of protein nanomaterials inside silica membranes: Physical incorporation of protein nanofibers into silica-based membranes requires the preparation of highly well-dispersed protein nanofiber arrays. Additionally, the functional integration of these materials with silica membranes requires that their electrical transport properties become better understood. Thus, our efforts have focused on both the synthesis of well-dispersed protein nanofibers and their integration with microfabricated electrodes as a means for the evaluation of electrical transport properties. We have successfully integrated well-dispersed protein nanofibers within the membranes, but have yet to realize a sample which is suitable for transport characterization studies.

Proposed Future Activities and their Potential Impact: Develop methods and testing capabilities for characterizing the protein nanofibers within the membrane. For example, frequency-based transport measurements are needed as we suspect that ionic transport may play a significant role the overall transport characteristics in these materials.

This project has been completed.

FESC
Florida Energy Systems Consortium

Florida State University

Investigating the Effect of Appliance Interface Design on Energy-use Behavior

PI: Paul Ward **Co-PIs:** Ian Douglas, David Eccles
Students: A. Dachoach (Ph.D., Psychology), J. Evans (Ph.D., Psychology), J. Torof (Post-bacc, Psychology/Masters, Educational Psychology & Learning Systems), S. Robertson (Ph.D., Educational Psychology & Learning Systems), K. Kudluckova (Ph.D., Educational Psychology & Learning Systems), G. Arsal (Ph.D., Educational Psychology & Learning Systems)

Description: The primary objective of this research project is 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 uses 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: $163,949
Universities: FSU

Executive Summary

First, there is some important information to report. In August of 2010, the PI on this project, Dr Paul Ward, left FSU to take a position at another institution and was unable to continue to run the project. Dr Ward had taken on the sole responsibility for the day-to-day supervision of the student assistants. To this point, the role of the Co-PIs on the project had been to provide conceptual support on ad hoc, needs-led basis to the PI. With only 4 months remaining, it was not possible to move the project beyond the trajectory it had taken under the previous PI. Consequently, the report prepared reports mainly on the activities of the graduate students who had worked on the project prior to the PI's departure and who assumed much of the remaining work on the project.

An extensive literature review and summary were prepared. A data base of existing energy efficiency initiatives, programs and reports pertaining to energy conservation, interface design and energy-use behavior was developed. A database was created that contains Energy Project Organizations and Contacts, which contains about 20 references for organizations and contacts related to this area. A survey entitled "Energy Survey" and designed to collect data about householder energy use behavior. The graduate students working on the project administered this survey to households in the local area and received response from 30+ households. These data are currently being analyzed and the results will be submitted at least as a conference presentation but potentially as a journal article publication.

This project has been completed.

FESC
Florida Energy Systems Consortium

Florida State University

Marketing Strategies to Incentives Entrepreneurship and Innovation in the Development of Sustainable Energy

PI: Joe Cronin **Faculty:** Jeff Smith
Students: Mark Gleim (PhD), Stephanie Lawson (PhD), Jeremy Wolter (PhD)

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: $278,778 (total), $102, 564 (yr 2)
Universities: FSU

Executive Summary

The research team has made tremendous strides during the reporting period in meeting many of the goals. Currently five papers have been published in the proceedings of national or regional conferences, including our premiere American Marketing Association conferences. Further, six conference presentations have been given on sustainability related topics funded through the IESES grant. In addition, four invited presentations have been given at different universities across the country. Numerous articles of research are also under review at various journals, or nearing the process of submission to select premiere marketing journals.

This project has been completed.

FESC
Florida Energy Systems Consortium

Florida State University

Microgrids for a Sustainable Energy Future

PI: Chris S. Edrington **Co-PIs:** Helen Li, Juan Ordonez, Jim Zheng, Mischa Steurer

Description: The primary aim of the project was to address R&D in the area of microgrids. Specifically the focus was in the area of PV and PHEV integration, microgrid modeling and control, grid-tying inverters/converters, energy storage, tri-generation, and standards development for smart grids.

Budget: $719,333
Universities: FSU

Executive Summary

Project Impact and Conclusions: Several students were able to participate in the research effort and thus able to obtain their graduate degrees, this helping in the overall goal of increasing an educated energy-oriented workforce. Additionally many publications were written that helped not only to disseminate the results of the work, but also to improve the reputation of research initiatives in the State of Florida.

Proposed Future Activities and their Potential Impact: It is hoped that additional funding in this area will continue to be awarded, especially in the areas of grid-impact studies as it pertains to PV's and PHEV's, as well as those in the areas of energy storage and management. It is essential that the impact of renewable and intermittent energy sources be thoroughly explored in order to ensure their reliability. Additionally, energy storage, its placement, and coordinated and controlled usage is essential in creating a fossil-fuel-free society.

This project has been completed.

FESC
Florida Energy Systems Consortium

Florida State University

Meteorological Factors Affecting Solar Energy Efficiency in the Tropics

PI: Paul H. Ruscher **Co-PIs:** (and formerly, Hans Chapman, Yaw Owusu)

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 are reviewed in this paper, using a state-of-the-art solar energy model. 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 will demonstrate the sources for these data as well as strategies for teaching about solar energy efficiency using routine observations from school-based weather stations.

Budget: $14,481
Universities: FSU

Executive Summary

Project Impact and Conclusions: The establishment of new monitoring stations that allow for the collection and integration of meteorological and solar energy data will improve our ability to ascertain solar energy efficiency as well as the role that various meteorological factors play in decreased efficiency, compared to that expected from industrial ratings of solar systems. The utility of a Department of Energy approved model, SMARTS, has also been demonstrated. This model allows for a wide range of experiments designed to focus on those factors that can have the most benefit (or detriment) to an efficiently and well-designed solar energy system for those pursuing such applications. It also helps to understand some unmet needs, particularly with respect to the adverse effects of cloudiness which are not directly treated in SMARTS, and which are only crudely attempted in most engineering applications.

Proposed Future Activities and their Potential Impact: I will be submitting a proposal to DOE/NREL for proposed improvements to monitoring and modeling solutions that were brought about during this research. It will also help to develop further applications of these methods with our Caribbean partners and other locations where solar energy can be expected to be of widespread use. A long-term goal is the development of a new ASTM standard for solar energy rating systems appropriate for the tropics, as suggested by Case et al. (2008).

This project has been completed.

Florida Energy Systems Consortium

Florida State University

Multi-Generation Capable Solar Thermal Technologies

PI: A. Krothapalli
Students: Jon Pandolfini (Ph.D.)

Description: The objective of the proposed research is 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.

Budget: $544,226
Universities: FSU

Executive Summary

The solar simulator has been ordered and constructed. A frame for the array is built out of 80/20 extruded aluminum. Power supplies and control circuits allow the lights to be controlled to a desired constant power. Analysis was conducted by graduate student J. Pandolfini under the direction of B. Greska and A. Krothapalli. The solar simulator was determined to be cost effective.

This project has been completed.

FESC
Florida Energy Systems Consortium

Florida State University

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

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 seeked 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.

Budget: $15,000
Universities: FSU

Executive Summary

This project has been completed.

Florida State University

Planning Grant: Climate Modeling and Outreach Activities

PI: Shawn R. Smith **Co-PIs**: Steve Cocke, David Zierden, James O'Brien, Julie Harrington
Students: Cristina Collier / B.S. Meteorology (completed May 2010)

Description:
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
Universities: FSU
External Collaborators: Mark Powell (National Oceanographic and Atmospheric Administration)

Executive Summary

The preliminary research confirms the existence of an offshore wind resource; however, the winds are not as strong as they are in regions where offshore development is underway on the U. S. East Coast. There continues to be a need for a more detailed wind resource assessment and the work of this IESES project has stimulated interest at the National Renewable Energy Laboratory to complete the coastal wind resource maps. Once a good resource assessment is complete, more effort will be needed in the areas of marine spatial planning, economics, and engineering to build a case for which regions have economically viable wind. There will be a need for technological improvements in turbine technology to produce at lower wind speeds.

In terms of outreach, the project has worked to change the attitudes within the renewable energy community and the state legislature that wind needs to be considered for Florida.

This project has been completed.

Florida State University

Planning Grant: Enhanced Thermal Performance and Microstructure Simulation of Nuclear Fuels

PI: Justin Schwartz

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, we 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 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 (UO_2, PuO_2, ThO_2 and MO_X), and initial studies into BeO coatings on HfO_2 particles, where HfO_2 serves as a benign surrogate for nuclear fuel oxides. We conducted an evaluation of possible coating processes and measured their thermal behavior. We used these findings to pursue external funding.

Budget: $15,000
University: FSU

Executive Summary

This project has been completed.

Florida State University

Planning Grant: High Performance and Low Cost Fuel Cells for Future Vehicles

PI: Jim Zheng **Co-PIs**: Richard Liang, Chuck Zhang, Ben Wang
Student: Michael Greenleaf, Ph.D. student at ECE department.

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.

Budget: $15,000
Universities: FSU
Research Integration (collaboration): NCSU and NHMFL, Industrial Engineering, Maxwell Technologies, Inc. and Ionova Technologies, Inc., CAPS, MARTECH, Shanghai Institute of Technical Physics

Executive Summary

The catalytic electrode was developed using carbon nanotube film (buckypaper) as a supporting medium through use of the electrodeposition method. Buckypapers are free-standing thin films consisting of single-walled carbon nanotubes, carbon nanofibers held together by van der Waals forces without any chemical binders. Mixed buckypapers may be developed by layered microstructures with a dense and high-conducting SWNT networks at the surface, as well as large porous structures of CNF networks as supports. This unique microstructure may improve Pt catalyst accessibility and the mass exchange properties. Pt particles were uniformly deposited in porous buckypaper and had an average particle size of about 6 nm. A promising electrochemical surface area of about 40 m2g-1 was obtained from these electrodes.

Due to their unique microstructure, buckypaper-supported platinum (Pt) catalysts derived from carbon nanotube and carbon nanofiber have demonstrated a high utilization in proton exchange fuel cells. The durability of a buckypaper-supported catalyst was investigated using an accelerated degradationtest in a mimic cathode environment of PEMFC. Compared to commercial carbon black-supported buckypaper showed better catalyst durability after holding at 1.2 volts for 400 hours; specifically, almost 80% of electrochemical surface area was lost for carbon black, while only 43% loss for buckypaper. Transmission electron microscopy and cyclic voltammetry were used to study the Pt degradation mechanism. It was concluded that Pt coarsening and detachment from buckypaper support due to carbon corrosion make the major contribution to the Pt surface area loss under this condition. It is supposedly due to the higher corrosion resistance of buckypaper because of its high graphitization degree which is indicated by a slower formation rate of surface oxides in buckypaper than in carbon black.

This project has been completed.

Florida State University

Planning Grant: Hydrogen Storage using Carbon-Based Adsorbent Materials

PI: Efstratios Manousakis

Description: We propose to theoretically investigate 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 propose to carry out a full theoretical investigation to find the optimum conditions.

Budget: $15,000
Universities: FSU

Executive Summary

This project has been completed.

FESC
Florida Energy Systems Consortium

Florida State University

Political and Economic Institutions Regarding Siting of Energy Facilities

PI: R. Mark Isaac **Co-PIs:** Douglas Norton, Svetlana Pevnitskaya
Students: Sean Collins and David Johnson.

Description: The "holdout" problem occurs when one economic agent attempts to construct a portfolio of economic assets (often land) from multiple sellers. When a public good has diffuse public benefits but costs concentrated on a few, a "NIMBY" problem (Not In My Back Yard) may exist.

Budget: $43,663
Universities: FSU

Executive Summary

The "Hold-Out" project (with graduate student Sean Collins). 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.

Our results are unambiguous: we observe the hold-out problem in our baseline design. In fact, in about half of the cases the contracting fails. This means that we have successfully created a test-bed which we can use to investigate institutional and information conditions that might ameliorate hold-out. Our second experimental treatment has been completed, and again the results are unambiguous: contingent contracting significantly ameliorates the hold-out problem.

A version of this research was one of the chapter's Dr. Sean Collins' dissertation. Sean has just joined the faculty of Fordham University. We are working on restructuring the paper from a dissertation chapter format to that of a journal article, and our intention is to submit it to *The Journal of Law and Economics.*

The "NIMBY"project (with Co-PIs Doug Norton and Svetlana Pevnitskaya).
The project operates at the intersection of economics and sustainable energy and the environment, the fundamental nexus of IESES, because the siting of alternative energy facilities is often driven by economic, organizational, and environmental considerations. The Tallahassee experience with the bio-mass plant was a perfect example of the heterogeneous public goods valuation problem.

The experimental design and programming are complete, IRB approval was obtained, and the first twelve experimental sessions have been conducted. The first presentations of the design were at the 2009 Southern Economics Association meetings and the 2010 American Economics Association meetings. The first public presentation of the results was at the 2010 World Meetings of the Economic Science Association in Stockholm in July, and it will also be presented at the International Social Dilemmas Conference at Rice University in September and the Southern Economic Association Meetings in November.

This project has been completed.

FESC
Florida Energy Systems Consortium

Florida State University

Promoting Energy and Land Use Through Land Use, Transportation and Green Infrastructure Policies

PI: Tim Chapin **Co-PIs**: Ivonne Audirac, Chris Coutts, and Greg Thompson, Mark Horner

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
Universities: FSU, Griffith University (Bisbane, Australia), University of Florida

Executive Summary

The project began in May 2009 and continued through the end of the 2010 calendar year. During the spring and summer 2010 terms, the research team finalized its review of the current state of knowledge in the issue areas, as well as completed our review of state and local energy and climate change policies and outlined the report. We have also completed interviews with key informants at key state agencies and with planners in local governments that have taken the lead on this issue in the state, and discussed our findings with key informants in non-profit agencies and within the land development industry. We also continue to identify potential outside funding sources for continued work on this initiative.

We continue to work on generating a report similar to the *Tough Choices: Shaping Florida's Future and Facing Florida's Revenue Shortfall* document prepared by the Collins Institute. This report summarizes the literature on the links between urban development patterns and energy sustainability/climate change and makes recommendations for state policies and programs to address these issues. The intention is to author a report that is easy-to-read, including graphics, and will highlight the key policies and programs the state should pursue to achieve its energy sustainability and climate change goals.

This project has been completed.

Florida Energy Systems Consortium

Florida State University

Real-Time Power Quality Study For Sustainable Energy Systems

PI: U. Meyer-Baese **Co-PIs:** Helen LI, Simon Foo, Anke Meyer-Baese, Juan Ordonez
Students Supported: Jinglin Xu (Ph.D.), Indranil Bhattacharya (Ph.D.), Zhichao Wu (Ph.D.), Liming Liu (Ph.D.)

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
Universities: FSU

Executive Summary

A large amount of data ranging from photovoltaic, PWM, fuel cell to custom microprocessor design has been collected during the time of the award and will enable the Principal Investigators to submit proposals in these areas. The team produced seven refereed conference papers, one journal paper, and one book has been published with IESES support.

This project has been completed.

FESC
Florida Energy Systems Consortium

Florida State University

Reducing Residential Carbon Emission in Florida: Optional Scenarios Based on Energy Consumption, Transportation, and Land Use

PI: Tingting Zhao **Co-PI:** Mark Horner
Students: John Sulik, Tim Kelleher, PhD students

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/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 CO_2 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 CO_2 and hence affect the intensity and origins of carbon emissions.

Budget: $21,707
Universities: FSU

Executive Summary

The initial proposal of this project consisted of three major steps: 1) calculating the Florida baseline CO_2 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.

This project has been completed.

FESC
Florida Energy Systems Consortium

Florida State University

Sustainably Integrated Advanced Building Subsystems (OGZEB)

PI: A. "Yulu" Krothapalli **Co-PI:** Justin Kramer
Students: Shannon Ingersoll

Description: This project focuses 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 is the Off-Grid Zero Emissions Building, which will allow 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.

Budget: $503,168
Universities: FSU

Executive Summary

This project has been completed.

FESC
Florida Energy Systems Consortium

Florida State University

The Future Florida Grid: Ensuring a Reliable and Resilient Electrical Energy Transmission and Delivery System in a Changing Environment

PI: Steinar Dale **Co-PIs:** Tom Baldwin, Omar Faruque, James Langston, Peter McLaren
Rick Meeker, Karl Schoder, Mischa Steurer
Students: Thamer Alquthami, Harsha Ravindra (MS Electrical Engineering)

Description: The project research goal is to address the challenges of the reliable flow of electrical energy throughout the state as the power system is transformed to include significantly more renewable and alternative sources, possible expansion of new very-large centralized base load (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: $359,642
Universities: FSU

Executive Summary

There has been substantial progress in the development of research-oriented models of the Florida electric power grid, the ultimate aim being models with sufficiently representative behavior for investigation of wide-ranging scenarios and options in future development of the grid. The analysis of the Florida Power Grid Disturbance has been used as a means for an initial comparison and validation of model behavior against real grid response. This approach has been demonstrated using an aggregated 14-Bus dynamic model with refinements in the data and protection related switching events, with results matching the recorded data observed in the incident report with minor discrepancies. Results suggest that the reduced, 14-bus model version may be useful, with reasonable assumptions, for some simplistic studies. Work is underway to construct parametric studies to determine the parameters sensitivity in the simulation using factor screening and other statistical techniques.

Though the 14-bus Florida grid model may be sufficient for some simple studies, the project's objective requires a more detailed benchmark system of the Florida grid. Therefore, a 154-bus notional electrical grid of Florida was built with detail representation using data available in the public domain. Reasonable model power flow results have been produced, and, efforts have proceeded to develop a dynamic model for the 154-bus system. The dynamic model requires data for each unit of generators, exciters, turbine governors, power system stabilizers, automatic generation controls and all the required protective devices with accurate settings. Where lacking complete details on each power plant's generation units, models for generators, exciters, and governors were chosen for the large plant or known plant at that bus. If information is available, models for the exact type of generation units are chosen. Typical data were assigned for the specified dynamic model parameters.

The development of a dynamic solar PV model with Maximum Power Point Tracking has been initiated and completed. The model will contribute to the general power system modeling and simulation community as we intend to make it publicly available and to the envisioned Florida Grid studies of future load and generation growth specifically. Initial studies of the impact of solar PV-based resources have been undertaken, and significant implications for power system operation and stability have been

observed. The depicted bus frequency traces after tripping of a solar PV-power plant at different penetration levels reveal unacceptable frequency deviations in the present model.

Advanced dynamic excitation systems and controls were added to the notional Florida grid model based on detailed, IEEE recommended, models for exciters and power system stabilizers. Case studies have been performed using PSS/E to evaluate the dynamic performance. Protections are also being added to the model so that realistic responses with respect to disturbances can be simulated.

A simulation effort was completed for a major municipal electric utility in the state to examine power system restoration from a complete system outage. This is expected to continue with further examination of system dynamics under different scenarios and possible development of simulation-assisted training.

Project Impact and Conclusions: The goal of this project was to address the challenges of the reliable movement of electrical energy throughout the state as the power system is transformed to include more renewable and alternative sources, increased use of distributed energy resources and microgrids, possible expansion with very-large centralized base load generation, and incorporation of new power conversion, transmission, measurement, communication, and control technologies. Consistent with this goal the researchers conducting this project

- have developed knowledge and understanding of the unique geographical challenges and their spatial solutions, which a Florida specific sustainable energy economy must address for aspects of a successful sustainable energy strategy, specifically transmission, base load and distributed generation, renewable resource integration, and their impact on Florida grid reliability and accommodating a range of energy conversion options. Initial work focused on collection and organization of information relating to load and generation projections for the state over the next 10-20 years. This information, based primarily on load and generation projections from ten year site plans submitted to the FRCC by Florida utilities and county-based population projections, will form the basis for probabilistic models of loads in future years.
- have developed several reduced models of the Florida transmission grid for research use and have conducted preliminary validation and investigations into effects of high amounts of intermittent resources on Florida grid performance with these models.
- have engaged with Florida's governing and advisory entities, such as the FRCC, Governor's Energy Office, Tallahassee EDC Energy and Environment Roundtable, in strategic power and energy matters for a sustainable energy economy.
- have leveraged synergies with work from other funding sources such as DOE
- have disseminated results through publications.
- have written a number of proposals, several successful.

This project also engaged graduate students in rigorous, relevant, and impactful research.

Proposed Future Activities and their Potential Impact: Future steps involve further refinement of the dynamic model of the Florida grid and development of relevant case scenarios to study the possible impacts of variability due to the intermittent power sources. In addition, the future plan also involves continued engagement with the FRCC and FL utilities toward the validation of the notional Florida grid model for the purpose of conducting studies of major variations in the make-up of the grid, providing insight into model reduction for large (many thousands of buses) grid models, providing insight into real-time and EMTP type grid modeling versus load-flow and dynamic single phase grid models, and supporting the utility industry and other stakeholders involved in the operation, maintenance, and planning of the electric power grid.

This project has been completed.

Florida State University

Visiting Law Professor

PI: JB Ruhl and Jim Rossi **Co-PIs**: Uma Outka
Student: Rebecca Lowrence

Description: Two-year Visiting Scholar at the College of Law researching 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.

Budget: $79,879
Universities: Florida State University, College of Law

Executive Summary

During the reporting period completed a second lengthy written work: *The Renewable Energy Footprint.* This article is the first to take a critical view of existing and emerging siting frameworks in light of the millions of acres that energy development will consume over the coming decades. The piece builds on Ms. Outka's state-level analysis of the first article, *Siting Renewable Energy: Land Use and Regulatory Context*, which was revised for publication in Ecology Law Quarterly (University of California-Berkeley) during the reporting period. *The Renewable Energy Footprint* argues that site-fixated regimes fail to address cumulative land impacts and that the siting context alone is insufficient to do so. The article develops instead the claim that cumulative land impacts must be a central consideration in the development and implementation of energy policy.

This project has been completed.