University of Florida

Economic Impacts of Renewable Energy and Energy Efficiency Policies

PI: Theodore Kury
Students: Colin Knapp, Ph.D. (Post-doctoral Fellow)

Description: PURC is engaging in three new research projects that will provide important information for policy makers in Florida. The projects are:

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. Proponents of state and federal policies promoting renewable energy and energy efficiency policies often assert that the policies will have positive impacts on jobs, specifically the so called green jobs.

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.

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: $150,000.00
Universities: University of Florida
External Collaborators: NA

Progress Summary

Work has continued on evaluating the effects of Renewable Portfolio Standards (RPSs) on state-level employment. These policies have become a popular policy in state capitals across the country. As of 2010, 36 states and the District of Columbia had adopted programs which fall under the RPS umbrella. The reasons often cited for the adoption of these programs include; increasing the share of electricity generation from renewable sources, thus lowering greenhouse gas emissions and reducing the threat of global climate change; increasing security by moving towards national energy independence; and creating job growth by dedicating expenditures towards industries or technologies not represented within a state's current mix of employment opportunities. These outcomes are supported by a vast *ex ante* literature which forecasts results using input-output analysis and economic forecasting models.

The purpose of this project is to approach the employment claim from a purely *ex post* perspective and measure the effect an RPS has on state-level employment. Initial results suggest a best-case scenario where every job created by an RPS is equally offset by job losses elsewhere in the state. Alternative specifications suggest a worsening employment situation with net job loss in those states which adopt an RPS. Additional results suggest that RPSs do not significantly increase the amount of energy generated from renewable sources in these states. This appears because the establishment of these guidelines is done with little enforcement of realistic and intermediate targets, making the policy an 'empty promise'. The effectiveness of alternate programs, such as mandatory green power purchasing

programs, suggests that the 'field of dreams' mentality that surrounds RPSs may be misguided and other options might exist which help satisfy some of the same goals.

Annual Progress Report

Initial work on the effect of renewable portfolio standards (RPS) has been completed. This includes the literature review, data collection, and data analysis concerning the effect of RPS implementation on state-level employment. An initial version of the results was presented during a seminar given to Ph.D. students studying regulation at the University of Florida on April 19, 2011. Feedback was received and incorporated into the project. The updated version of the paper was written and presented to the FESC 2011 Summit. This generated additional comments and revisions which were added to the paper. During the 2012 Public Utility Research Center (PURC) Annual Conference, PURC's Executive Committee requested the opportunity to review the paper prior to submission to an academic journal. The most current version of the paper was submitted to each Executive Committee member. Substantive comments were received from one member. This led to follow-up discussions concerning the research design and potential avenues for improving the paper. Several suggestions have been incorporated into the paper which is now being edited prior to submission to *The Journal of Regulatory Economics.* Following submission of the peer-reviewed article, attention will be given to the remaining projects outlined in the description.

University of Florida

Energy Intensive Crop Development

PIs: Gary Peter, Matias Kirst, Don Rockwood
Students: Alejandro Riveros-Walker, (Ph.D.), Jianxing Zhang, (Ph.D.), Patricio Munoz (Ph.D.)

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: $240,000
Universities: UF
External Collaborators: N/A

Executive Summary

Our long-term *systems goal* is to develop environmentally sustainable, energy crops for maximum biomass productivity, carbon sequestration and optimal conversion to biofuels and bioenergy. To achieve this long-term goal, we proposed to conduct fundamental research aimed at identifying genes that control growth and biomass chemical composition, and applied research aimed at providing important yield and chemical composition information for a variety Eucalyptus and pine which can be grown in Florida. Wood chemical composition was a central theme as this relates to the amount of energy or biofuel that can be obtained.

This project has been completed. The final report can be found here.

University of Florida

Engineering Biocatalysts for Hemicelluloses Hydrolysis and Fermentation

PI: James F. Preston

Description:

Budget: $192,000
Universities: UF

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

Executive Summary

Different forms of lignocellulosic biomass represent major renewable resources derived from solar energy via photosynthesis. Several of these are abundant in the southeastern United States and amenable to development as major sources of fuels and chemicals. Energy crops, poplar and energy cane, and agricultural residues, sugarcane bagasse and sorghum, are candidates for bioconversion to targeted products. The hemicellulose fraction, representing 20 to 30% of these resources, may be efficiently converted, via secreted xylanolytic enzymes, to sugars for intracellular metabolism and conversion to biofuels and chemicals by fermentative bacterial biocatalysts.

We have identified and characterized xylan-utilization systems from bacteria at the gene and enzyme level, and applied the appropriate enzymes for efficient conversion of xylans to fermentable pentoses, xylose and arabinose. This has led to the identification of bacteria for the secretion of xylanolytic enzymes, assimilation of the products of extracellular depolymerization of xylans, followed by efficient intracellular metabolism. Xylanolytic bacteria, e.g. *Paenibacillus* spp., are candidates for downstream engineering to produce lactate or ethanol. Other bacteria capable of fermentation, e.g. *Bacillus subtilis*, have been engineered for secretion of xylanolytic enzymes for optimal conversion of hemicelluloses to lactate and ethanol. These developments will provide new biocatalysts for consolidated bioprocessing of hemicelluloses for cost-effective conversion of lignocellulosic resources to alternative fuels and chemicals.

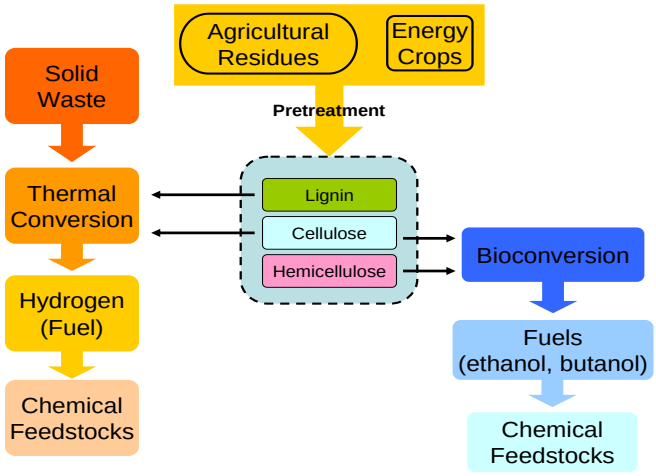
The genome sequence of *Paenibacillus* sp. JDR2 (Pjdr2) has been completed, and has identified genes an endoxylanase, an α-glucuronidase, and an arabinofuranosidase have been cloned and expressed in *E. coli* to produce recombinant enzymes for the efficient conversion of xylans to arabinose, xylotriose , xylotriose. These products of depolymerization can be assimilated and fermented by *Klebsiella oxytoca* and *Enterobacter asburiae* strains engineered for production of ethanol and lactate. These bacterial biocatalysts are able to convert cellobiose derived from cellulose-digested cellulose and xylooligosaccharides derived from xylanase/α-glucuronidase-digested hemicelluloses to targeted fermentation products. With the added complement of cellulolytic and xylanolytic enzymes these strains are promising candidates for the efficient bioconversion of alkaline-treated lignocellulosics from hardwoods and grasses to bioethanol and chemical feedstocks.

Genes related to the xylanolytic enzymes defined in Pjdr2 have been identified other bacteria including the thermophillic xylanase from *Thermotoga maritima*. The gene encoding this xylanase has been

produced as a recombinant protein in tobacco and sugarcane for saccharification of lignocellulosics on an industrial scale.

While the complete integrated conversion of cellulose and hemicelluloses to a targeted fermentation product, e.g. ethanol, may be desirable for an operation dedicated to the formation of that product, it may be desirable to have variable streams for production of different product classes. This might apply to a biorefinery in which the lignocellulosic biomass may be processed to provide lignin, cellulose and hemicelluloses for production of materials as well as biofuels and chemicals. A biocatalyst developed with *Paenibacillus* JDR2 might then efficiently process hemicellulose to ethanol or lactate, with the cellulose going other products as shown below.

Flow Chart for Biomass and Solid Waste Conversion to Energy



If the conversion of cellulose is desired along with hemicelluloses, commercial cellulases might be added to the hemicellulose fermentation as long as the cost of these enzymes is justified by market conditions

This project has been completed. [The final report can be found here](#).

University of Florida

Integrated PV/Storage and PV/Storage/Lighting Systems

PI: Franky So

Co-PI's:

Students: Cephas Small / PhD candidate
Song Chen / PhD candidate
Tzung-Han Lai / PhD candidate

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
Universities: UF
External Collaborators: University of California San Diego, Oak Ridge National Lab

Executive Summary

In this final report, we will summarize the work we have done in OLED, PV and lithium ion batteries. In the area of lighting and photovoltaics, we focused on light management and hybrid light emitting and PV devices. We have made use of "defective" grating structures to extract thin film guided modes in OLEDs. Because of the lack of long range ordering, we were able to achieve lambertian-like emitters with a 2X enhancement in light output. We have also developed novel optical structures for enhancing the efficiency of organic and hybrid organic-inorganic photovoltaic cells by allowing the active materials to more efficiently absorb the incident light. Two different optical structures were created and applied to the PV cells using a soft lithographic process, which could be easily implemented in large-scale high throughput manufacturing systems. Such enhancement mechanism could also be universally applied to any active materials or device platforms. For hybrid solar cells, we have significantly improved the efficiency of hybrid polymer-colloidal nanocrystal solar cells by engineering the chemical and electronic structures at the polymer-nanocrystal interface. This yields a maximum power conversion efficiency of 5%, the highest for solid-state hybrid solar cells. Finally, we also developed fully solution processed, multilayer quantum-dot based light-emitting devices that show high efficiency and full visible spectrum color tunability.

Lithium-ion batteries are efficient, light-weight and rechargeable power sources for consumer electronics such as laptop computers, digital cameras, MP3 players and cellular phones. However, for the use as energy storage component in this proposed work, the energy density, power density safety and cycling performance still can't achieve the requirements. In this research, three different strategies were selected to improve the rate capability, cycling performance and investigate the solid electrolyte interface. First, the first principles computation was used to selected suitable doping metal and proved by real experiment. Second, the TiO_2 nanostructure was synthesized and the electrochemical properties were examined. Finally, the thin film batteries were fabricated by pulsed laser deposition (PLD) and the solid electrolyte interface were investigated by XPS. In addition, the layered lithium excess layered oxide compounds $Li[Ni_xLi_{1/3-2x/3}Mn_{2/3-x/3}]O_2$ ($0 < x < 1/2$) are of great interests as a new generation of positive electrode materials for lithium-ion batteries because of higher energy densities and lower costs. However, the rate capabilities of these materials are not adequate for future applications. Preliminary studies have proposed mechanisms to explain this material's anomalous capacity; however the mechanism still remains unclear. In order to break the rate capability barrier, a complete understanding of the lithium diffusion mechanism needs to be understood. We uses a series of characterization techniques to identify the rate limiting step that impedes lithium diffusion and propose new strategy to further improve the electrochemical properties of this new family of electrode materials.

This project has been completed, the final report can be found here.

University of Florida

Joint Optimization of Urban Energy-Water Systems in Florida

PI: James P. Heaney
Students: John McCary (PhD) and Miguel Morales (PhD)

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 an 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
Universities: UF
External Collaborators: Florida Department of Environmental Protection, South Florida, Southwest Florida and St. Johns River Water Management Districts, Gainesville Regional Utilities, Hillsborough County Water Utility Department, Sanford Water Utility, Water Research Foundation, Austin, Texas, Intelligent Software Development, United States Geological Survey

Background and Significance
The energy-water nexus for Florida is shown in Table 1. Water for power generation is a large user of fresh surface water and the dominant use of saline surface water. Agriculture is the largest user of fresh water and this use could grow significantly to support biofuel initiatives. All public water supply and most other water uses require that the water be delivered under pressure. Public water supplies consume about 4% of the nation's electricity (Sandia 2007). Per capita energy demands for supporting water supplies in Florida are expected to increase since cities are being required to meet future increases in water demand from more energy intensive alternative sources such as desalination and reuse.

[Compiled by the U.S. Geological Survey, Tallahassee; all values in million gallons per day]

Florida 2000	Freshwater			Saline Water		
	Ground	Surface	Total	Ground	Surface	Total
Public Supply	2,199.36	237.43	2,436.79	0.00	0.00	0.00
Domestic self-supplied	198.68	0.00	198.68	0.00	0.00	0.00
Commercial-industrial self-supplied	430.70	132.60	563.30	0.00	1.18	1.18
Agricultural self-supplied	1,989.95	1,933.06	3,923.01	0.00	0.00	0.00
Recreational irrigation	230.45	181.28	411.73	0.00	0.00	0.00
Power generation	29.53	628.73	658.26	3.82	11,950.82	11,954.64
TOTALS	**5,078.67**	**3,113.10**	**8,191.77**	**3.82**	**11,952.00**	**11,955.82**

Table 1. Total water withdrawals in Florida by category in the year 2000 (Marella 2004).

All electric vehicles are estimated to withdraw ten times as much water and consume up to three times as much water per mile as gasoline powered vehicles (Webber 2008). Biofuels have an even bigger impact on water supplies due to increases in irrigation water demand, and crop processing for conversion to biofuels can consume 20 or more times as much water for every mile traveled than the production of gasoline (Webber 2008). Low cost irrigation water is no longer available in most parts of the United States.

Examples of the interrelationships between energy and water are shown in Figure 1. Energy use for supporting public water supply activities can be divided into two major components: 1) the energy needed to deliver the water to the end user; and 2) the additional energy use by the end user for water heating, clothes washing and drying. Energy use at the end use level is the greater of the two components in California accounting for 14% of California's electricity consumption and 31% of its natural gas consumption, mostly in the residential sector (Electric Power Research Institute 2003).

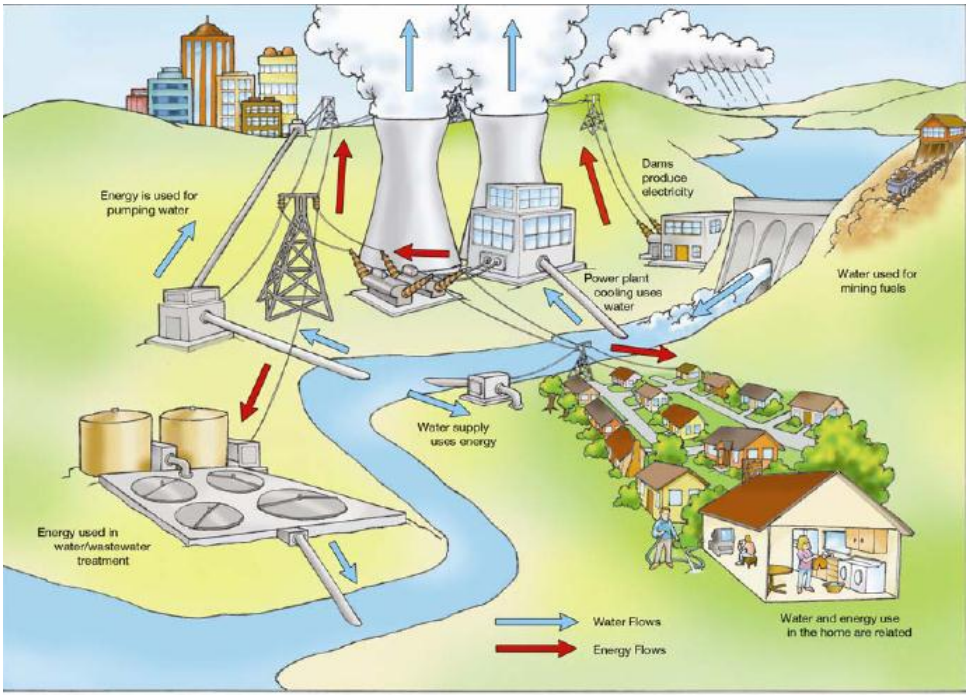


Figure 1. Examples of interrelationships between water and energy (Sandia 2007).

Energy-water efficiency simulation/optimization model

We have developed an urban water conservation evaluation model for Florida called EZ Guide as part of ongoing research. Three papers were accepted for publication in a national journal (Friedman et al. 2011, Morales et al. 2011) and a Florida water journal (Heaney et al. 2011) that describe the EZ Guide methodology. More complete information is available at web site for the Conserve Florida Water Clearinghouse (www.conservefloridawater.org). The current version of EZ Guide is available online and the data are uploaded automatically once the water utility boundaries are specified. The current funding does not provide support to include energy considerations in an in-depth manner. The funding from this project will allow us to add this critical element in our June 2013 release of EZ Guide. The water-energy methodology is described in a water-energy nexus paper by Morales et al. (2013) that has been submitted for publication to a national journal.

Energy Management in Water Systems

Urban water systems are required to deliver adequate quantities of water to customers continuously. The quality of this water must be suitable for drinking. This water must be delivered at suitable pressures. Sophisticated hydraulic simulation models are available to evaluate the flow rates, water quality, and pressures throughout the network. A current goal is real-time control of energy expenditures to meet these demands. We have partnered with Hillsborough County Water Utility Department to evaluate energy management options for their system. The primary work was done by Mr. John McCary who is an engineer with Hillsborough County and a part-time PhD student at the U. of Florida. The results of this analysis showed the potential energy savings in the distribution system of an actual test utility in Hillsborough County (McCary and Heaney 2012).

Accomplishments

Water use analysis is typically done using utility-wide data since it is too difficult to organize and evaluate customer level attribute and monthly water billing data. A major breakthrough in the research of the Conserve Florida Water Clearinghouse has been the acquisition and use of customer level attributes including land use information, and utility level monthly water use data for every utility in the State of Florida. Thus, annually updated attribute and GIS data are available for nine million parcels in Florida and can be downloaded from the Florida Department of Revenue (FDOR) web site (ftp://sdrftp03.dor.state.fl.us/). Each of Florida's 67 counties has a property tax assessor's (CPTA) database that contains information that is included in the FDOR database and other attributes that are of interest in that county. The information in the county databases varies from county to county but the county data can be linked to the state database with a Unique Parcel Number. This information is of high quality since it is the basis for estimating property taxes. The key land use information for a parcel is its impervious and pervious areas. This information can be extracted directly from the FDOR/CPTA databases. The type of land use is available for 64 land uses based on an FDOR land use code. Population information can be obtained from US Census data at the Census Block level of aggregation. Water utility service areas may not be contiguous with the political boundaries of the cities. Fortunately, the three largest of the five water management districts have developed GIS coverage that enables one to assign parcels to the appropriate utility. These data sources can be combined to estimate the long-term trends in attributes of interest.

All utilities in Florida are required to submit Monthly Operating Reports (MORs) to the Florida Department of Environmental Protection (FDEP) that include information on daily water supplied by each treatment plant, water quality data, and information on the population served and the number of connections. Twelve years of monthly water use data are available for each utility from the FDEP web site (http://www.dep.state.fl.us/water/drinkingwater/download.htm) for every water treatment plant in Florida. This information can be used to evaluate historical trends and to project future growth patterns.

This information is compiled into software called EZ Guide that is used to find the optimal water conservation plan. Energy costs associated with end uses, e.g., showers, is being included in EZ Guide. This valuable additional information allows for a much more accurate bottom up assessment of the interdependencies between water and energy.

The other initiative is to evaluate how to minimize energy costs associated with urban water supply. The methodology builds on our earlier research on water distribution systems (Lippai et al. 1999) and includes a case study of the Hillsborough County water system. A state of the art hydraulic simulation model is used that calculates the spatial and temporal variability in flows, pressures, and water quality.

Benefits to the state

Florida seeks to be a leader in developing innovative energy systems that will reduce our dependence on foreign oil and generate energy related jobs. The Florida Energy Systems Consortium will develop numerous innovations to address our needs for more energy. Concurrently, we face unprecedented challenges to meet our growing needs for more water. Florida is blessed with a relative abundance of high quality water, especially ground water. These water sources have been a major component of the economic engine that has nurtured Florida's development over the past century. However, beginning in 2013, Florida water users will not be allowed to tap traditional low cost, high quality, water supply sources to meet their new needs because their supply has dwindled to low levels. Thus, we are running out of low cost energy and water at about the same time. Worse yet, many of the newer energy and water sources require more intensive use of these two resources, e.g., desalination of sea water is much more energy intensive than pumping from a nearby groundwater source; biofuel production requires far greater amounts of water to grow the crops and support the conversion process. National studies warn of the impending energy-water conflict (Cohen et al. 2004, Electric Power Research Institute 2003, National Research Council 2008, Navigant Consulting 2006, Sandia 2007, Webber 2008). Facing such dire circumstances, attention is shifting to developing more efficient systems and reducing our demands, where possible, through conservation. This project addresses how to evaluate energy-water linkages and find better ways to manage the demands for energy and water as a cost-effective way to reduce our future needs. It is essential for Florida to understand these water-energy trade-offs so that it can avoid myopic solutions that address one problem to the detriment of the other.

This study integrates energy evaluations into our ongoing Conserve Florida Water Clearinghouse (CFWC) project that is addressing water use efficiency and conservation. CFWC already has a network of state agencies, water management districts, water utilities and professional water organizations. The results of this study will be disseminated in the form of software tools and technical papers to allow users to do accurate integrated evaluations of water and energy systems.

How funds were leveraged

The inclusion of energy evaluations in the EZ Guide model will help minimize the damage to our base funding for the Conserve Florida Water Clearinghouse. We incurred a 60% reduction in base funding in June 2011, primarily due to the major budget cuts suffered by the water management districts. Fortunately, we were successful in obtaining new funding from St. Johns River Water Management District and the city of Sanford to develop new methods for water loss management. At present, Sanford has unaccounted for water in the range of 20-25% resulting in excess energy demand and reduced revenue. The goals of energy conservation and water loss control are synergistic. We also competed successfully for a national study of commercial, industrial, and institutional water use sponsored by the Water Research Foundation of the American Water Works Association. We are collaborating with Hazen and Sawyer, Inc., a recognized leader in this field. We are also collaborating with Austin, Texas, a leader in water conservation, in adapting our Florida methods for other utilities. Finally, the United States Geological Survey is supporting the research of one doctoral student related to urban infrastructure optimization

Reference to full report

A more complete description of the results of this project are contained in the final report.

This project has been completed. The final report can be found here.

University of Florida

Low Cost Solar Driven Desalination

PI: James Klausner
Students: Fadi Alnaimat/Ph.D. Mechanical Engineering

Description: Water and energy scarcity poses a future threat to human activity and societal development around the world. The state of Florida is vulnerable to fresh water shortages. Florida ground water is contaminated in many locations from leaky underground tanks, agricultural pesticides, and other chemicals. Although it is possible to desalinate sea water, conventional systems are energy intensive. Solar energy utilization for desalination systems is being investigated to provide adequate fresh water for the state's needs. Solar diffusion driven desalination (DDD) system has been developed for both bulk water desalination and small community needs/disaster response. The research objective is to examine the best operating condition for the solar diffusion driven desalination (DDD) process using a computer models developed for the transient evaporation and condensation processes. The outcome of the study is the development of cost effective, low power consumption, and low maintenance desalination process that is powered by solar energy. Several operating modes for the solar DDD process have been investigated, and the best operating mode is used to design a small scale distillation unit. In addition, one of the main operational difficulties encountered in thermal distillation processes is the cooling requirement. Cooling is needed to reduce the condensing water temperature in the condenser to increase water production. In this study, the external cooling requirement has been tackled with a unique operating mode.

Budget: $252,000
Universities: UF

Executive Summary

Within the United States there are many regions that face severe fresh water shortages. Areas in the Southwest U.S. are sparsely populated and centralized desalination is not economical due to the long transport distances required. Instead, de-centralized desalination driven by solar energy is an approach that has significant economic potential. The outcome of this project is the development of a low temperature, low cost, inexpensive, solar driven desalination technology that is well suited toward the individual user. The technology is called Diffusion Driven Desalination (DDD). Thermal heat and mass transfer models have been developed as a design, analysis, and scaling tool. Several operating modes for the solar DDD process have been investigated, and the best operating mode is used to design a small scale distillation unit. In addition, the solar heat input is recycled in a unique transient mode so that it does not require an external source of cooling water. A detailed analytical investigation suggests that this process can potentially produce 100 liters per day distilled water with an average specific electric energy consumption as low as 3.6 kW-hr/m^3 using a total of eight 2 m^2 solar collectors. Water production and energy consumption have been investigated under various design and operating conditions. A unique operating mode has been explored to improve the water production and reduce the specific energy consumption. The study has shown that operation in the delayed mode significantly reduces the specific electric energy consumption compared with operation in the conventional mode. It is believed that the solar DDD process, with its low power consumption and low maintenance requirement is a competitive desalination technology that is well suited for small scale decentralized water production.

This project has been completed. The full report can be found here.

University of Florida

Non-Contact Energy Delivery for PV System and Wireless Charging Applications

PI: Jenshan Lin

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
Universities: UF

Executive Summary

This project studied an innovative approach to deliver electrical power from outdoor photovoltaic energy source to indoor electrical appliances without using any wire penetrating through building structures. The approach is based on wireless power transfer using near-field magnetic coupling. Operating in lower radio frequency bands of MHz and below, where the wavelength is much longer than the distance of transfer, the energy coupling occurs locally and does not radiate. Therefore it is safe to the environment and the residents. The technique would enable the photovoltaic system to be quickly set up or disassembled for relocation, and the collected solar energy from outdoor system can be conveniently delivered to indoor appliances. The technique can also be used for wireless charging of many portable electronic devices.

During the project, we focused on near-field magnetic coupling and studied different architectures of wireless power transfer. Two prototypes were built to demonstrate wireless power delivery of 38.3 W with 76% efficiency and 114 W with 65% efficiency, respectively, over a distance of one meter. Sensitivity to alignment and coil rotation pitch were also investigated. It was found that the system is not sensitive to alignment and rotation pitch as long as the coupling coils are not completely offset with zero projection overlap and not rotated by more than 45°. While large metal obstacles between coils may cause the efficiency degradation, small metal objects such as nails, wires, and rods have almost no effect on the system performance. The results demonstrated the effectiveness of wireless power system and the applicability of wireless power transfer technique to PV systems and wireless charging of electronic equipment.

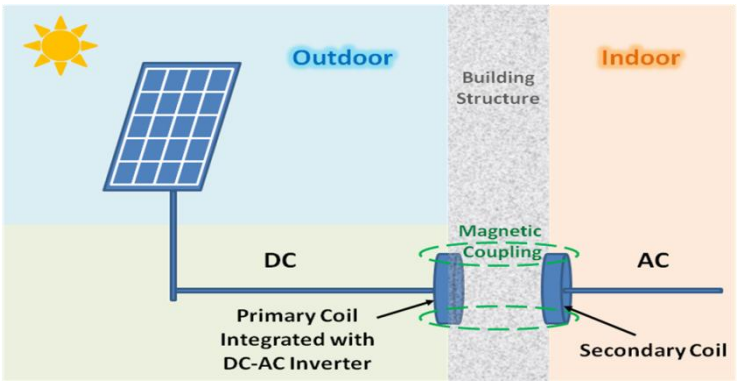


Figure 1: Concept diagram of the noncontact wireless power delivery system

Figure 1 shows the concept diagram of the noncontact wireless power delivery system. Since no wire is need to go through the building structures, the installation cost and time can be reduced. The system can be easily installed and uninstalled if necessary. No wire is exposed, making it suitable for conditions where full insulation is required. This technique has the potential to lower the installation cost and time and promote the use of solar energy.

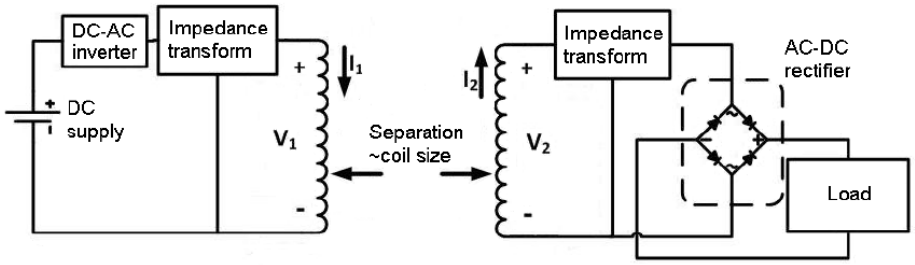


Figure 2: Block diagram of the wireless power transfer system using magnetic coupling.

Figure 2 show the block diagram of the of the wireless power transfer system using magnetic coupling. A DC-AC inverter converts the DC electricity from PV cells. After impedance transformation, the energy is coupled to the receiver through magnetic coupling. After coupling, the AC energy goes through impedance transformation and AC-DC rectifier, and the DC energy is delivered to the load. The wireless energy coupling is accomplished by two coils separated by a distance. Through the study, it was found that the optimum separation distance is about the dimension of the coil. In other words, to achieve a certain coupling distance, the dimension of the coil must be roughly equal to the distance. We have used both square shape and circular shape coils and both achieved good results.

The DC-AC generation requires high efficiency inverter. Both Class-D and Class-E topologies for DC-AC inverter were studied. Class-D topology has been commonly used in power electronics, and has the advantages of less device stress and more robust to impedance variation. Class-E topology, on the other hand, has advantages of higher power delivery and uses only one transistor while Class D needs two transistors. With the same DC supply voltage, Class-E can deliver more AC power than Class-D. However, since Class-E has only one transistor, the voltage stress on transistor is higher in Class-E than in Class-D. Table 1 shows the comparison between these two topologies. It can be seen that to deliver same amount of power, the transistor drain voltage stress in Class-E is 2.112 times than in Class-D. However, for the same DC supply voltage, Class-E can achieve 2.847 times power delivery than Class-D.

Initially, Class-E was adopted in our research. It was effective for shorter coupling distance. However, we later found out that the Class-D, especially the full-bridge Class-D, is better for mid-range wireless power system where coupling distance is about the same as the coil dimension. The efficiency remains constant when power level is changed, and is less sensitive to variation in distance when compared to Class-E. The full-bridge Class-D also requires half of the supply voltage of Class-D and is suitable for higher power applications when device breakdown voltage is a limiting factor. Figure 4 shows a picture of the full-bridge Class-D inverter we built.

	Constant variable	**Class E normalized to Class D**
Drain voltage stress	Supply voltage	3.562
Drain voltage stress	Power delivery	2.112
Power delivery	Supply voltage	2.847
Supply voltage	Power delivery	0.593

Table 1: Comparison between Class-E and Class-D DC-AC inverters

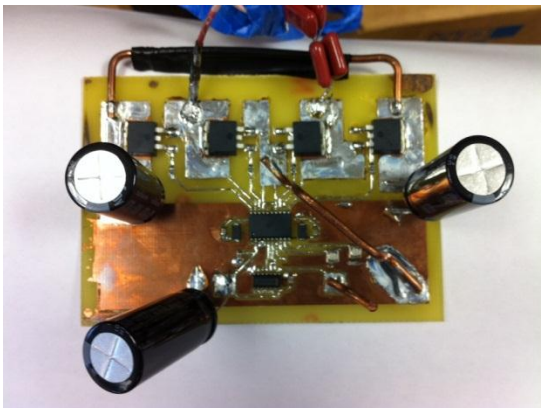


Figure 3: Full-bridge Class-D inverter.

Different impedance transformation circuits were studied. In the end, series LC resonant topology was chosen for its simplicity. In this configuration the system efficiency was derived as:

$$\eta = \frac{\omega^2 M^2 R_L}{(R_2 + R_L)^2 R_1 + (R_2 + R_L)\omega^2 M^2}$$

It can be seen that there are two methods to increase efficiency. First, the mutual inductance should be increased. This was achieved by making the dimension of the coupling coils similar to the distance desired. Second, the efficiency can be increased by reducing the parasitic resistance (R_1 and R_2) of the coils themselves (as well as the series resistance of any other components). To minimize these values, litz wire as well as ¼" copper pipe were used in the construction of the coils.

In our experiment, we built two systems to demonstrate the wireless power transfer. In the first system, two coils made of litz wire on wooden forms are used (Figure 4). Fixed film capacitors are used for series tuning. A full-bridge amplifier using IRF530 MOSFETs and a HIP4081A driver are used to power the system operating at 500 kHz. The maximum power transferred using this system is 38.3 W with 76% efficiency. The transmitted power is limited primarily by the high voltage that develops as a result of the series resonant circuit. The high voltage will cause arcing between turns of the litz wire and breakdown of the capacitor used to tune the circuit. These faults can damage the driving amplifier.

Figure 4: The first wireless power system achieving 38.3 W with 76% efficiency. The coils are made of litz wire: 6 turns, 1 m each side, 1725 strand, 48 AWG.

The second system utilizes ¼" copper pipe (Figure 5) to form two 1-m diameter helical coils. A higher voltage rated capacitor is formed from several film capacitors in parallel with a 10 kV vacuum variable capacitor for fine tuning. Using this system, a maximum power of 114 W was delivered to a 25 Ω load with 65% efficiency at one meter separation. Virtually all of the dissipated power is lost to the resistances of the coils, not in the amplifier, thus the amplifier should be able to supply up to 450 W without further modification, which should allow for received power to approach 300 W.

Figure 5: The second wireless power system achieving 114 W and 65% efficiency. The coils are made of ¼" copper tubing on PVC form: 9 turns, 1 m diameter.

The research results were published in several international refereed journals and conference proceedings and presented in several conferences and invited talks. The results attracted attentions from researchers

worldwide. Three companies from Taiwan, Japan, and Korea sent their engineers to University of Florida for collaborative research projects. The collaborative research projects also brought in external funding from these companies. Overall, this project made an impact globally and attracted researchers and engineers to Florida. It also attracted research funding to University of Florida.

This Project is complete. The final report can be found here.

University of Florida

Optimization of Algae Species for Biofuels Production Using Genetic Alteration

PI: Edward Phlips
Student: Bailey Trump, PhD degree

Description: The central challenges to viable algal biofuel production are the solar energy conversion efficiency for algae growth, sustainable yields of usable products and operational constraints on production systems. While theoretical solar conversion efficiencies for algae and plants are between 5 and 6% of total insolation, most algal systems operate at average annual efficiencies well below this range. Therefore large areas are needed to produce significant amounts of biofuels from algae, and production systems must be able to sustainably produce biomass convertible to biofuels within reasonable logistical and economic constraints. Logistical constraints include minimal use of valuable freshwater and arable land resources. Economic constraints may demand the use of low tech open pond systems, rather than more costly and maintenance intensive closed bioreactor designs. Sustainability of production will depend on the ability to maintain relatively pure mass cultures of algae capable of producing high levels of desirable products (e.g. hydrocarbons or convertible lipids). These considerations point toward the need to focus on the development of systems which use ocean water and algal species adaptable to extreme conditions that minimize competition from "weed" species, such as high salinity, temperature, pH, low nitrogen availability or UV light exposure.

The focus of this study is genetic alteration of 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. The research program began with the use of chemical mutagens to generate altered strains of algae currently available in the culture collection of the PI (E. J. Phlips). Mutated algae are going through a selection process to identify strains with favorable characteristics. The selection criteria include growth rate, tolerance to environmental extremes (e.g. salinity, temperature, pH, UV exposure), and lipid content. The initial target species for mutagenesis research will include: 1) *Botyrococcus braunii*, a green alga (Chlorophyta) known for its high levels of hydrocarbons, but low growth rates and low adaptability to high salinities and temperatures, 2) *Synechococcus sp.* a fast growing cyanobacteria high biomass production potential, and adaptability extreme environmental conditions, such as high salinity and temperature.

Budget: $15,000
Universities: UF
Collaborators: Drs. Mathius Kirst in the University of Florida's Genetic Institute and Charles Guy in the Department of Environmental Horticulture at the University of Florida.

Executive Summary

A major challenge that the United States and the world is facing is how to produce clean, renewable energy in a cost effective manner with minimal environmental impacts. The research in this study was aimed at developing such a technology by synergistically combining blue-green algae (i.e. cyanobacteria) grown in outside ponds with anaerobic digesters to produce renewable natural gas (RNG). The research focused on a remarkable marine cyanobacterium that needs neither fresh water (grows in saline conditions) nor externally supplied nitrogen and produces large amounts of extracellular polysaccharide that can be effectively used as a substrate for RNG production. Whereas current algae-based approaches rely on producing lipids, which subsequently requires energy intensive separation processes, the approach taken here uses the algae suspension directly to produce methane gas. Furthermore, by re-cycling the

waste CO2 produced during the digestion process to enhance algae growth, a higher quality fuel gas is generated and greenhouse gas emissions are reduced.

The long-term focal points of our reseach are: 1) Selection of species with eco-physiological characteristics uniquely well suited for application in saline open pond biomass production systems, 2) Development of an innovative approach for the conversion of algal biomass into biofuels, and 3) Genetic alteration of selected species of algae to optimize their performance in biomass production systems aimed at biofuels. The species selection criteria used for the study funded by FESC in 2011/2012 included growth rate, tolerance to environmental extremes (e.g. salinity, temperature), and chemical content convertible to biofuels. For the FESC project we selected a strain of marine cyanobacteria, *Synechococcus sp* 0011, previously isolated from a coastal lagoon near the Florida Keys. This cyanobacterium (blue-green alga) grows rapidly with nitrogen obtained through nitrogen fixation and secretes large quantities of polysaccharide.

In addition to species selection, efforts were initiated to develop a process for producing methane by coupling algae production with salt tolerant methanogenic systems that we are currently operating. The use of *Synechococcus* Sp. 0011 in the production system offers the following benefits: 1) Compatibility with open photobioreactors containing saline media, thereby avoiding the use of limited freshwater resources and reducing the potential for contamination by undesirable species, 2) Secretion of energy-dense polysaccharide into the surrounding media, which can either be converted to methane without separation or recovered for use in ethanol production through a low-energy separation method and 3) Fixation of atmospheric nitrogen, thereby avoiding the use of fossil derived nitrogen nutrients.

Biomass and polysaccharide production rates of *Synechococcus* Sp. 0011 were explored using laboratory mesocosms. The focus of the study was tolerance to salinity variation, which is a critical issue is the sustainability of open-raceway production systems using marine water. The results of the mesocosm experiments demonstrate that *Synechococcus* Sp. 0011 is tolerant to salinities from 5 (near freshwater) to 70 psu (twice the concentration of ocean water). It also demonstrates an ability to adapt elevated salinities, as evidenced by the increased rates of growth with longer term exposure to high salinities.

In the Fall of 2011 we formed a new research collaboration with Drs. Pratap Pullammanappallil of the Department of Agricultural and Biological Engineering (U. of Florida), Spyros Svoronos of the College of Engineering (U. Florida) and Ben Koopman of the College Engineering (U. of Florida) to help develop a technology for the conversion of algal biomass into renewable natural gas. Preliminary results indicate that *Synechococcus* Sp. 0011 is a viable substrate for methane production, but additional research is needed to arrive at definitive conversion rates.

In the Fall of 2012 the genome of *Synechococcus* Sp. 0011 will be sequenced by Bailey Trump at the University of Florida Genetics Institute with the assistance of Dr. Mathius Kirst. This is an important step toward the next goal of genetically modifying the species to improve on its already unique properties. The availability of a sequence will also aid in the eventual patent process. In addition, genetic alteration of *Synechococcus* Sp. 0011 will be explored, using mutagenesis and genetic transformation approaches. The research program will begin with the use of chemical mutagens to generate altered strains. Mutated algae will go through a selection process to identify strains with favorable characteristics.

From a broader perspective, the research team is currently focusing on detailed design elements of the new technology. A seed grant to help the development effort was awarded to the team by Florida Sea Grant in 2012. A full proposal for future research and development is being prepared for submission in 2013.

This project has been completed. The final report can be found here.

University of Florida

Optimization, Robustness and Equilibrium Modeling for the Florida Smart Grid

PI: Panos Pardalos
Students: Alexey Sorokin / PhD

Description: The purpose of this research is to develop models and algorithms for optimal design and functioning of the nation's next generation power transmission and distribution system that will incorporate the new realities of the grid. Our goal is to create innovative real time capabilities for 1) optimal functioning of renewable energy sources (location, charging, discharging of batteries, etc.), 2) detecting and preventing instabilities and outages, and 3) operating models including generalized Nash equilibrium.

Budget: $30,000
Universities: UF

Progress Summary

The project develops a game theoretic approach for electricity market participants with storage devices. With electricity prices changing continuously over day storage devices can be used to reduce electricity consumption during peak-hours as well as reducing electricity prices, carbon emissions and peak transmission loads. However, if everyone shifts their demand toward a period when electricity is cheaper, that will have an inevitable effect on electricity price and will not lead to significant reduction of a peak demand but rather shift it for another period of the day. The goal is to develop a model for "smart batteries" – a plan for charging and discharging batteries in such a way that every participant will enjoy the maximal possible gain. The model developed in the project formulates a Nash equilibrium problem and propose extensions for generalized Nash equilibrium. In the simplest case, our model presents a Nash equilibrium problem with quadratic cost functions. It is attacked with several methods recently developed.

Funds leveraged/new partnerships created:
Steffen Rebennack, PhD,
Assistant Professor
Colorado School of Mines
Division of Economics and Business
816 15th Street
Golden,CO, 80501, USA

Neng Fan, PhD
Sandia National Laboratories

2011 Annual Report

We consider a problem of micro-storage management where household communities have common batteries installed and can buy electricity from the grid for home use, for charging the battery, or can use battery for the house when the current electricity price is high.

The objective is to develop a model such that every agent minimizes the cost for electricity and battery running cost. The model describes a Nash equilibrium problem and proposes extensions for generalized Nash equilibrium. While the theory of the generalized Nash equilibrium is well developed, its computation is a challenge. The difficulty stems from the fact that the Nash equilibrium is a fixed point of an appropriate mapping, and its calculation goes beyond the optimization theory. In the simplest case, our model presents a Nash equilibrium problem with quadratic cost functions. It is attacked with several methods recently developed. With electricity prices changing continuously over day storage devices can be used to reduce electricity consumption during peak-hours as well as reducing electricity prices, carbon emissions and peak transmission loads. However, if everyone shifts their demand toward a period when electricity is cheaper, that will have an inevitable effect on electricity price and will not lead to significant reduction of a peak demand but rather shift it for another period of the day.

Assumptions:

- There are several communities present and together they can affect electricity price by changing electricity demand.
- Every community shares a common battery.

The first assumption leads to Nash equilibrium problem, i.e. the solution of each agent problem depends on the rest agents. The second assumption leads to a generalized Nash equilibrium problem, which is much more difficult. Both models are new and difficult to solve. The fact that several communities work on Nash equilibrium problem (without knowing each to other) shows the importance and applicability of this model where non-cooperative equilibrium is sought.

0.1. **Agents.** There is a set of agents (customers) A who want to minimize their electricity cost. The agents form communities i, which are presented in a set I. An agent has a load profile l_t^{ia}, which shows the demand for electricity at any time moment $t \in T$ not considering the battery charging/discharging. The sum of load profiles among the agents of all communities will define the total electricity demand at time moment $t \in T$: $d_t = \sum_i \sum_a l_t^{ia}$. Every agent has an access to a common battery within a community i with the following parameters:

- total capacity e^i,
- efficiency α^i,
- running cost c^i,

For minimizing the cost, an agent a can change their storage profile b_t^{ia}, $\forall t \in T$: $-b_-^i + \sum_{A/a} b_{t-}^i \le b_t^{ia} \le b_+^i - \sum_{A/a} b_{t+}^i$, where b_-^i is a discharging capacity of the battery and b_+^i is charging capacity of the battery. Clearly, the charging profile for an agent a at time moment t is a difference between the amount charged and discharged : $b_t^{ia} = b_t^{ia+} - b_t^{ia-}$. Summing up over all the agents we get the net storage profile: $b_t = \sum_i \sum_a b_t^{ia}$.

0.2. **Market.** Total amount of electricity bought from the market at time moment t is $q_t = d_t + b_t$. The market price of the electricity is defined by supply curve of that market, which is assumed to be a nondecreasing: $p_t = s_t(q_t)$ and each agent will pay $p_t \cdot (l_t^{ia} + b_t^{ia})$. Total cost of electricity for all the agents will be $p_t \cdot q_t$.

I	Set of communities
A_i	Set of agents within community i
T	Set of time periods
l_t^{ia}	load profile – demand not considering battery use
$d_t = \sum_i \sum_a l_t^{ia}$	Total electricity demand at t
e^i	battery total capacity
α^i	battery efficiency, if q is charged then $\alpha^i q$ is discharged
c^i	battery running cost
b_t^{ia}	storage profile – amount of electricity charged/discharged at time moment t by an agent a in a community i
b_-^i	Discharging capacity of a battery i
b_+^i	Charging capacity of a battery i
b_t^{ia+}	Amount of electricity charged at time period t
b_t^{ia-}	Amount of electricity discharged at time moment t
q_t^{i-}	Amount of electricity that can be discharged in battery i at time moment t
q_t^{i+}	Amount of electricity that can be charged to battery i at time moment t
p_t	Price of electricity at time moment t

The Model:

Every agent minimizes the cost for electricity and battery running cost:

(1) $$cost^{ia}(b^{ia}) = \sum_t \left(p_t \cdot (l_t^{ia} + b_t^{ia}) + c^i \cdot b_t^{ia+}\right)$$

s.t.

storage profile:

(2) $$b_t^{ia} = b_t^{ia+} - b_t^{ia-}, \ \forall i \in I, \ a \in A, \ t \in T,$$

total daily charging can not exceed battery capacity:

(3) $$\sum_a \sum_t b_t^{ia+} \leq e^i, \ \forall i \in I,$$

battery efficiency constraints:

(4) $$\sum_a \sum_t b_t^{ia-} = \sum_a \sum_t \alpha^i b_t^{ia+}, \ \forall i \in I,$$

charging profile feasibility constraints:

(5) $$\sum_a b_t^{ia+} \leq q_t^{i+}, \ \forall i \in I, \ t \in T,$$

(6) $$\sum_a b_t^{ia-} \leq q_t^{i-}, \ \forall i \in I, , t \in T,$$

(7) $$q_t^{i-} = \alpha^i \left(q_0^{i+} + \sum_a \sum_{k=1}^{t-1} (b_k^{ia+} - b_k^{ia-}/\alpha^i) \right), \ \forall i \in I, t \in T,$$

(8) $$q_t^{i+} = e^i - \left(q_0^{i+} + \sum_a \sum_{k=1}^{t-1} (b_k^{ia+} - b_k^{ia-}/\alpha^i) \right), \ \forall i \in I, t \in T,$$

electricity reselling is not allowed:

(9) $$l_t^{ia} \geq b_t^{ia}, \ \forall i \in I, \ a \in A, \ t \in T.$$

Activities:

Organized conference (Organizer Panos Pardalos)
Systems and Optimization Aspects of Smart Grid Challenges
April 28-30, 2011 Gainesville, Florida, USA

Presented talk: "**Game Theoretic Approach for Micro-storage Management in the Smart Grid",** by Pando Georgiev, Alexey Sorokin, Marco Carvalho and Panos Pardalos.

Accepted talk at the INFORMS conference, November 16
"Nash Equilibrium Model for Micro-storage Management in the Smart Grid"
by Alexey Sorokin, Pando Georgiev, Marco Carvalho and Panos Pardalos.

Working towards to publish the results in this talk in a journal paper.

Ongoing work on data mining in energy for detecting and preventing instabilities and outages of the power grid.

Edited books:

Handbook of Networks in Power Systems I co-editors: Alexey Sorokin, Steffen Rebennack, Panos Pardalos, Niko Iliadis, Mario Pereira, Springer, (2011).

Handbook of Networks in Power Systems II co-editors: Alexey Sorokin, Steffen Rebennack, Panos Pardalos, Niko Iliadis, Mario Pereira, Springer, (2011).

University of Florida

Outreach Activities for the Florida Energy Systems Consortium

PI: Pierce Jones
Co-PIs/Outreach Team Members: Kathleen C. Ruppert, Hal S. Knowles III, M. Jennison Kipp Searcy, Nicholas Taylor, Barbra Larson, Craig Miller
Students: Sarah Dwyer (MS), Flavio Hazan (Ph.D.), Hal Knowles (Ph.D.), Nicholas Taylor (Ph.D.)

Description: UF's Program for Resource Efficient Communities (PREC) develops 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: $497,671
Universities: UF
External collaborators: Tampa Bay Water, UF/IFAS County Extension Offices, American Water Works Association, River Network, Alliance for Water Efficiency, Florida Section of the American Water Works Association, American Council for an Energy Efficient Economy (ACEEE), St. Johns River Water Management District, Southwest Regional Planning Council, Florida State University, University of South Florida, University of Central Florida, Florida A&M University, Florida Atlantic University, Gainesville Regional Utilities, Clay Electric, Florida Progress Energy, Canin Associates, Inc., Orlando Utilities Commission, City of Tallahassee, etc.

Executive Summary

The Program for Resource Efficient Communities (PREC) promotes the adoption of best design, construction and management practices that measurably reduce energy and water consumption and environmental degradation in new residential community developments. Our focus extends from lot level through site development to surrounding lands and ecological systems. We support the implementation of these practices through direct training education and consulting activities, applied research projects/case studies, and partnering with "green" certification programs.

As the Energy Extension Service, and through the cooperation of the Extension offices in each county in Florida, we provide and deliver continuing education courses and associated certifications for professionals involved in the design, construction, and operation of residential community developments, including "Build Green & Profit" and "Low Impact Development (LID) Practices for Florida: Stormwater." Through this network and with the assistance of our diversified faculty, we deliver outreach activities for the Florida Energy Systems Consortium (FESC) in the areas of Energy/Climate Awareness Factsheets, demand side management programs, continuing education modules on applied energy efficient technologies, and collaboration on alternatively fueled vehicle research and data collection. By working collaboratively with the FESC universities, we help the citizens and communities of Florida make informed decisions on energy use and stimulate economic opportunities in the alternative energy and energy efficiency services sector.

Assistantships funded directly for students working on research projects contributing to promotion of resource efficient design, construction and management of master planned communities:

- Sarah Dwyer (MS): Use of metered utility data for evaluating residential energy-efficiency program performance;
- Flavio Hazan (PhD): Developing land planning GIS tools to account for resource consumption and greenhouse gas emissions;
- Hal Knowles (PhD): Developing internet-based social marketing tools to improve household energy management and applying fractal geometry-based nonlinear time-series analytical methods to diagnose the health of a home and its occupants as a unified system.

Completed four books:

- *Greenhouse Gas Reduction and Energy Conservation: Development Impacts Under Florida's HB 697*;
- *Energy Efficiency Retrofit and Renewable Energy Programs Using Property Assessed Financing: Florida Guide for Local Governments* (revised and update to *Options for Clean Energy Financing Programs: Scalable Solutions for Florida's Local Governments*);
- *Low Impact Development (LID) Design Manual for Alachua County, Florida*; and
- revised *Energy Efficient Building Construction in Florida*.

Completed six refereed articles with two more in process.

Completed 43 fact sheets (new or revised) with FESC faculty members from member institutions and others for the FESC website.

Completed two in-service trainings for county faculty; with one training open to the public. Participated in other departmental, regional and statewide (FESC Summit) trainings as well. Brought in county extension faculty as presenters and participants to the FESC Summits.

Co-developer of materials for the new Sustainable Floridians[SM] Program designed to motivate participants and create community-level leadership in sustainability education and actions in a variety of settings. Took over leadership and development of the program in 2012. The course was piloted twice in Leon, Marion, and Pinellas counties and expanded to include Osceola and Sarasota counties. Additional counties have shown an interest. Due to receiving an Extension Dean's award of $5,000, we will be offering an in-service training in February of 2013.

Worked with Florida 4-H on the *S.A.V.E.: Steps in Achieving Viable Energy* youth education outreach program and materials intended for middle-school aged youth. Florida 4-H previewed the curriculum at the FESC 2010 Summit in Orlando. The curriculum is designed for students in middle school and high school and also for 11-13 year-olds in afterschool programs or clubs. The program focuses on 4 areas of energy awareness: forms, sources, users and impacts. The afterschool and club program consists of 30 activities and can be used over a three year period. A website is also a part of the project to support the materials (http://florida4h.org/projects/SAVE.shtml).

The Pasco County School System is contemplating adopting the curriculum for 5th graders as the materials closely align with the new Florida Next Generation Education Standards. Other states, including Michigan and Montana, are interested in adapting the materials to meet their explicit educational requirements, specifically as related to STEM education

Demand Side Management:

Working with the Public Utilities Research Center at UF on a review of the Florida Energy Efficiency and Conservation Act legislation to help the Florida Legislature determine if the act remains in the public interest.

Retrofit and DSM program analysis: contracted with the Utilities Commission of New Smyrna Beach; Analyzed program impact of weatherization for low income families by local non-profit Community Weatherization Coalition; Worked with UF Shimberg Center and Alachua County Housing Authority to analyze impact of water heater retrofits in subsidized housing; FL DCA WAP analysis: worked with utilities and municipalities across the state to gather data.

Worked with OUC and Accelerated Data Works to create a website (http://ouc.toolsfortenants.com/) that provides multi-family housing *Tools for Tenants* to save energy, and thus money, through comparative feedback and conservation advice. The tool is based upon work supported in part by GRU, the City of Gainesville, OUC, the US DOE (via both SBIR and ARRA funding), and the Florida Department of Agriculture and Consumer Services Office of Energy (under grant agreement number ARS 134). This tool serves as a complement to a multi-family housing energy-efficient building improvement and performance analysis project backed by $429,000 in grant funded OUC rebate incentives for five apartment complex owners.

Continuing Education:

Developed several new continuing education courses for building professionals:

- *Energy Efficient Building Construction in Florida* – (8 hours) Reviews 8 key elements of energy efficient construction and identifies related benefits (economic, IEQ, comfort, durability…). Topics include: Building as a System; Air Leakage-Materials and Techniques; Insulation-Materials and Techniques; Windows and Doors; Design for Cooling and Heating (HVAC) System Efficiency; Duct Systems for Florida's Hot, Humid Climate; Domestic Water Heating; Appliances and Lighting; and Siting and Passive Design Features.
- *Greenhouse Gas Reduction and Energy Conservation: Development Impacts Under HB 697* – (6 hours) Explores the implications of HB 697 as a comprehensive planning matter and examines issues and best practices from other states with GHG regulations.
- *Remodel Green & Profit* - (6 hours) Establishes cost-effective measures for determining energy efficient retrofits and techniques for utilizing solar thermal and solar PV systems. Building "weatherization" techniques are addressed as a measure for energy and water retrofitting.

Workforce Development:

Worked on the US DOE (Weatherization Assistance Program Training Center) grant including Development of the Certification Training and comprehensive review of same. Corresponding training-the-trainer materials were also reviewed. Test questions were developed and prerequisites are being established with Workforce Florida and various Technical/Vocational Training Centers for student recruitment.

The basic weatherization course that was developed for in-person training is being developed as an online training opportunity that will be available in fall 2012.
Developed training materials for commercial energy analysis (including commercial lighting, plug loads, and motors) for a curriculum under development with the University of Nebraska to train commercial energy auditors. The training will be able to be used in Florida in the future.

Alternatively Fueled Vehicles:
Held in-service training for county faculty representing 16 counties and panel discussion for the public on PHEV Prius and charging station, potential for PHEV and EVs in Florida, Solar Electric Low Speed Vehicles, Solar Bicycle ASES Photon, Compressed Natural Gas, Liquefied Natural Gas and Liquefied Petroleum Gas, and Bio-diesel March 18, 2010, in Gainesville.

Worked with Florida Progress Energy to evaluate performance of PHEV using converted Toyota Prius equipped with GPS tracking system and software to monitor performance.

Collaboration on New Initiatives:
With Evident Energy, submitted proposals to the Energy Trust of Oregon and to the Ontario Power Authority to perform energy-efficiency measurement and verification services.

Worked on development of a proposal in response to an RFP from the Vermont Department of Public Service Planning and Energy Resources Division entitled "Evaluation of Energy Efficiency Programs and Market Research in Vermont's Single Family Existing Buildings Market." PREC would be a project partner and would provide measurement and verification services related to the Home Performance with Energy Star in Vermont.

Collaborating with UF's College of Design, Construction, and Planning to seek funding for development of computer-based tools to demonstrate energy and water impacts of planning scenarios.
Collaborated with the College of Design, Construction and Planning and Plum Creek in offering the Practicum in Sustainability and the Built Environment (DCP 4941) six-hour credit course for undergraduate students during Fall 2011 term. The end result was a report (*From Food to Community: A Systems Perspective for Urban Development*) on the energy, water, and material resource considerations of how residents might optimally eat, move, dwell, and commune within the 23,000 acre Plum Creek parcel under evaluation for development in Eastern Alachua County. Also, as a result of offering the course, one of the students received a summer 2012 internship in the area of sustainability with the Pinellas County Extension Service Office in Largo.

Collaborated with private and public sector leaders on the Alachua Clean Energy (ACE) effort to catalyze a local energy finance framework for energy-efficient building improvements and renewable energy
This Project has been completed, the final report appears here.