Florida Energy Systems Consortium
Science and Technology Thrusts

The Science and Technology Research of Florida Energy Systems Consortium (FESC) will initially be aligned with six thrusts that a panel of 12 of Florida’s leading energy technologists have determined must be pursued, if Florida is to meet its future energy needs, and at the same time sustain a robust economy. FESC has selected 13 initial tasks, or projects, in alignment with these thrusts that the State University System has the highest potential of generating near term impact, given its current makeup of SUS expertise and infrastructure. These thrusts and tasks are described below.

Thrust 1. Developing Florida’s Biomass Resources

Biomass offers tremendous opportunity as a major, near-term, carbon-neutral energy resource. Florida has more biomass resources than any state, ~10% of U.S. total. As such, harnessing these resources should be a key component of Florida’s energy strategy. Efficient biomass conversion, however, is a complex system depending on locally available resources (due to high shipping costs of low energy density biomass). For example, South Florida is a major sugar cane and citrus producing region; whereas, North Florida has abundant woody biomass resources. Therefore, the most efficient technologies to harness these resources are regionally specific and demand a systems approach. Cellulosic ethanol and gasification processes are just entering the early commercial phase and offer many opportunities for improvement. These improvements are urgently needed to reduce capital cost and facilitate commercial deployment, thus creating new industry and new employment for Florida. The SUS is an internationally recognized contributor to biomass energy research and harnessing Florida’s biomass energy resources is an essential mission of the Consortium.

Thrust 2. Harnessing Florida’s Solar Resources

The direct conversion of incident solar radiation to electric power is the ultimate sustainable energy source. Not only does it bypass photosynthesis and thus carbon, but it can be implemented also in a distributed mode and fed to an existing distribution system (grid). Florida is one of the richest states in solar radiation, receiving ~6 kWhr/m²/day. Therefore, the appropriate strategy for the Sunshine State is to include a significant solar component in its renewables package to offset growth in energy demand. This will be implemented in part by encouraging broad deployment of solar technologies and developing a Florida industry to meet the demand. Fortunately, the solar expertise resident in the SUS is one of the largest in the country and would serve as a research and education base to attract industry. The implementation of this strategy will require continued cost reductions, and systems integration will be central. Collecting this broad research expertise through a consortium approach would facilitate the translation of the solar innovations into more cost efficient systems.

Thrust 3. Ensuring Nuclear Energy & Carbon Constrained Technologies for Electric Power

Nuclear energy provides large-scale, carbon-free electric power generation today and will remain a major contributor to our power needs. Florida’s existing nuclear energy workforce at the five existing facilities will soon witness significant retirement. Additionally, an aggressive new plant strategy will require an expanded workforce. To meet these demands, an existing training reactor would be used to provide training in critical areas such as design, construction, operation, fuel reprocessing, and waste remediation.
Development of clean coal and natural gas power generation with carbon sequestration is important for a carbon-constrained world since fossil fuels are the largest contributor to electric power generation. Advances in efficiency, demand response and management techniques, carbon capture and sequestration technologies and how these can be integrated into new fossil fuel generation plants are critical to meeting energy demand at an affordable cost. A particular focus of this thrust is development of carbon sequestration technology relevant to Florida’s geography.

**Thrust 4. Enhancing Energy Efficiency and Conservation**

Energy efficient technologies have the greatest potential to reduce Florida’s energy consumption. The focus is improving existing and new construction building efficiency and energy system integration for sustainable community developments, industry energy auditing and efficiency, outreach, and education. Buildings use more energy than any other sector of the economy, including transportation and industry, thus making it a major efficiency target. The integration for sustainable community developments, industry energy auditing and efficiency, outreach, and education. Buildings use more energy than any other sector of the economy, including transportation and industry, thus making it a major efficiency target. The integration of innovative energy-efficient technologies into our building operations and construction will result in cleaner, healthier, and more sustainable and economically viable communities that are less susceptible to disaster. As part of the Consortium, well-instrumented testing structures will be established to evaluate the effectiveness of integrated emerging technologies as well as hurricane-level wind resilience.

**Thrust 5. Securing our Energy Delivery Infrastructure**

Increased electricity demand and severe weather adversely impact the reliability and resilience of Florida’s electric infrastructure. Resulting power interruptions are an economic hardship of several $B/yr and a threat to public safety. This will escalate as Florida’s population increases. The proposed diversified portfolio of distributed renewable generation will not become reality if electric infrastructure is not developed in conjunction with supply. Research includes investigation of grid topologies, equipment and systems (e.g., power electronics, transformers, and substations), revenue metering, monitoring and control aimed at improved reliability, power quality, availability and resiliency of the transmission and distribution system.

**Thrust 6. Energy Systems and their Environmental and Economic Impacts - overarching**

Florida’s industry, utilities, and government need sound advice and research on energy technologies and strategies to set a prudent course for the future. The implementation of effective economic policies is important to any energy system. The SUS should provide the State with expertise in energy and environmental economics and policy with insight into the economic and regulatory environment of the energy industry. Coupling the expertise in technologies for generating power, distributed resources, and reducing emissions with an understanding of cost-benefit/effectiveness analysis and policy are crucial to a systems approach and to the State. The expertise in this thrust will be used to evaluate the potential of our systems level goals to make a significant impact in the State. Moreover, significant changes are anticipated in our energy system and we need to fully understand the system’s response to policy change by developing analysis tools and Florida-specific databases. Therefore, the overarching goals of this thrust are to:

- Develop the systems evaluation and integration approach necessary for implementation of the energy technologies developed in the other thrusts.
• Provide a State resource for objective analysis of energy technology, environmental impact, economics, policy and law.

To have the greatest positive impact, a key strategy of the Consortium is to define systems level goals that not only drive the research agenda but also integrate innovation into validated energy systems that can be transferred to the commercial market. Use of these systems level drivers will allow the research to have shorter term (~3 yrs) and tangible focus, meld SUS-wide teams with common purpose, and allow progress to be better assessed. Vertically integrated Systems Goals (also referred to as Tasks for budgeting purposes) will also better convey the Consortium’s value and attract resources to sustain it.

The organization of FESC is thus a matrix of SUS expertise in specific thrust areas with multiple thrust areas focused on system level goals. To illustrate our system-level approach, consider the overall system to address Florida’s transportation and electric power needs utilizing its natural energy resources (Fig. 2). Inputs to the overall system are biomass and solar energy. Within that system are interrelated subsystems providing necessary functions to different sectors of the economy. Numerous other proposed systems that could not be included due to page limitations.

**Task 1. Integrated Florida Bio-Energy Industry**

Florida is biomass rich, which provides an alternative to conventional energy sources, environmental, rural economic growth, and energy security benefits. The growth of a bioenergy industry will generate needed sustainable energy for Florida, revitalize its agriculture, and create employment in the state. To maximize its impact on Florida’s future, however, the bioenergy industry needs to emulate mature industries such as oil, where the feedstocks are fractionated based on value and density and processed to maximize the yield of a diverse set of products (e.g., natural gas, gasoline, and diesel). Similarly Florida needs to fractionate its biomass resources based on value to produce a range of products from food to biofuels, chemical feedstocks and electricity (Fig. 3). Integration of these technologies and processes provides the potential for a Florida bioenergy industry that can then compete with conventional fossil fuel based industries without displacing our critical food supply.

**Energy Intensive Crop Development** - The first step in an integrated Bio-Energy industry is development of energy intensive crops. The proposed research will provide breakthroughs in identification of Florida energy crops and cultivars, development of best agricultural practices for production, and focused improvements using traditional and molecular genetic approaches. Energy crop research will focus on two groups, C-4 plants (e.g., cane and switch grass) and short rotation trees (e.g., pine and poplar). Natural cultivars will be screened for yield, and compositions that enhance digestion into ethanol. Deliberate gene changes will also be investigated to alter plant wall structure for efficient extraction and depolymerization of carbohydrates. The proposed research will: advance our knowledge of how plants partition...
carbon; identify genes to breed plants that are more readily extractable/digestible to increase conversion efficiency; establish best agricultural practices for production of Florida energy crops; and develop economic models to estimate costs and identify improvement opportunities.

**Biochemical Conversion of Florida’s Cellulosic Biomass to Liquid Fuels and Chemicals** - Biofuels and chemical feedstocks are the greatest value added products of this industry. Our focus is the biochemical production of alcohols to serve as a bridge-fuel to reduce dependence on imported petroleum and decrease net carbon emissions using a non-food, biomass feedstock. Florida has the potential to produce ~93 MT/yr of cellulosic materials, over 7% total U.S. production. Florida also has a leadership position in cellulosic ethanol development. Unlike corn ethanol processes, cellulosic ethanol is in the earliest stages of commercialization. Florida has provided $20M in construction funds to build a ~2M gal/yr cellulosic ethanol plant at Florida Crystals Corp. Once fully operational this facility will generate revenue to support research and design improvements and provide validation for diverse Florida feedstocks. FESC funds will support initial start-up operation and research opportunities that can rapidly advance bio-fuel technology.

This project will develop and demonstrate an integrated, multi-product biorefinery at pre-commercial scale to support a full economic and technical feasibility analysis for the use of Florida-grown feedstocks. The goal of this facility is to evaluate, validate, and improve processes, improve efficiency and decrease complexity, and accelerate full commercialization of cellulosic biorefineries in Florida. This facility will represent a complete test bed for new trial crops as well as existing municipal, forestry, and agricultural residues. This facility will complete the renewable cycle by converting solar energy stored in biomass from Florida fields into automotive fuels and chemicals to replace petroleum. Together with energy crop production, this project will provide a comprehensive demonstration of a “Farm to Fuel”/“Fields to Wheels” biorefinery to facilitate commercial development of renewable fuels in Florida.

**Integrated Biofuel, Hydrogen and Electricity Cogeneration from Biomass and Solid Waste** - Finally low value agricultural residues, as well as solid waste, are used to produce additional fuels, hydrogen, and electricity. The integrated system will incorporate technologies for conversion of biomass to biogas and subsequently H\(_2\), electric power and liquid bio-fuels. The task addresses the incorporation of a biorefinery into existing agricultural, municipal and industrial activities that produce organic wastes or byproduct streams. Anaerobic digestion (ADG) and thermal gasification will be developed for wet and dry, respectively, biomass resources. ADG will be developed to produce CH\(_4\)-rich streams that will be tested directly in a Siemens 3kW solid oxide fuel (SOFC) for electric power generation as well as for a feedstock in subsequent bio-fuel synthesis. Thermal gasification processes will produce H\(_2\) enriched synthesis gas. The resulting biogases will be analyzed for composition and utilized in a membrane reactor to produce pure H\(_2\) and in subsequent catalysis to create clean burning liquid hydrocarbon fuels (from ethanol and gasoline to diesel and JP8 jet fuel). The membrane reactor produces pure H\(_2\) from hydrocarbon feed stocks by internal steam reforming and water-gas shift reactions and the in-situ product removal drives H\(_2\) production to higher yields than are otherwise thermodynamically achievable. This will demonstrate the efficacy, cost advantages of H\(_2\) production from biomass, and advance the technology to the proof of concept scale for industry investment.

The fuels produced will be tested for combustion properties and electric power generation. SOFC operation on biogas would be the most efficient means of producing electricity from
Florida’s abundant renewable biomass resources. Siemens Power Generation (Orlando, FL) has identified biomass as a major part of its future growth and is teaming with UF on the proposed task. Optimization of the integrated system will be performed to help adjust gasification design parameters based on projected overall economics of H₂, biofuel and electric power production. A system economic and GHG reduction analysis, including mass and energy balances to determine overall efficiencies, will be carried out using data obtained from the operation of the individual components and the integrated system. Economic feasibility of a full-scale system will be performed, including effect of increased capital investment and feedstock transportation costs.

**Task 2. An Integrated Sustainable Transportation System**

A potential integrated sustainable transportation system is a plug-in hybrid electric vehicle (PHEV) charged by PV generated electricity while “plugged-in” and fuel cells operating on biofuel while in transit. Electric vehicles charged from solar PV are the ideal carbon free transportation. However, batteries do not currently give the desired driving range, so plug-in hybrids are the closest technology to achieving this dream of carbon-free transportation. A further dramatic improvement in efficiency and reduction in emissions would be achieved if the hybrid’s IC-engine was replaced with a fuel cell. SOFCs are the most efficient technology for directly converting the chemical energy of hydrocarbon fuels to electricity on a “well to wheels” system-basis, thus, producing the least CO₂/kWh from conventional fuels and if designed to operate on biofuel would both be carbon-neutral and operating on a renewable resource. For a PHEV-SOFC/biofuel vehicle to be commercially viable its operation must be transparent (within existing transportation fueling infrastructure) and cost competitive with current technology. To achieve this we will integrate Li-Battery and SOFC developments. If successfully developed this system would be a transformational change in transportation technology, potentially creating a new transportation industry in the state.

Energy storage is key to efficient use where demand and supply vary, ranging from HEVs to solar PV systems. Li-batteries are attractive due to high energy/power density. For HEV/PHEV further improvements in specific energy, energy density, and lifetime are necessary. To achieve these goals we will investigate higher voltage positive (olivine and spinel oxides) and negative (carbon nano-tube) electrodes that have potential for increased energy density and power. Research will focus on fundamentals of ionic transport, phase stability at high charged state and the electrode/electrolyte interface, combining relevant experimental techniques with first principles computational methods to identify factors that control Li mobility. We will also determine degradation mechanisms and design batteries with improved cycle life. State of the art SOFCs operate at >700°C; however, a UF team has developed the world record conductivity (100X conventional) electrolyte and achieved record cathode performance that operates as low as ~300°C. Therefore, our focus is anode and cell/stack development. We will develop direct-bioethanol anodes using catalytic conducting materials with controlled microstructures, integrate results, and fabricate and demonstrate complete low temperature biofuel SOFCs using the FISE Energy Technology Incubator.

We will also develop and optimize operating control systems and evaluate life-cycle costs of the PHEV-SOFC/biofuel vehicle, including total engineering systems analysis and economic accounting of GHG emissions from increased fuel efficiency in combination with the plug-in feature using PV for charging. The analysis will examine outcomes under different state and federal energy policy scenarios including potential efficiency rebates and carbon taxes.
Task 3. Solar Thermal Power for Bulk Power and Distributed Generation

Solar thermal power is the most advanced and economic technology for bulk (MW scale) power production. At present about 5000MW of solar thermal power is in design or construction, including 300MW by FPL. The biggest advantage of solar thermal power over PV is that they provide power for longer time by combining solar power during peak irradiance times and bio-fuel energy storage for off peak times. The present cost of power from these plants is ~11 c/kWh which can be reduced to <6 c/kWh with experience, larger capacities and mass production.

The proposed project will develop design methodologies, set up demonstration and test facilities, optimize for Florida conditions, develop and commercialize innovative thermodynamic cycle technologies, and develop control technologies for grid integration. Our approach will be to advance proven technologies for utility adoption while simultaneously developing new low cost and efficient technologies. We will develop test facilities and pilot demonstration systems at UCF, USF and UF and conduct technology evaluation and optimize plant operation strategies for Florida conditions. In addition, we will advance the novel USF thermodynamic cycle technology for combined power and cooling in cooperation with industry for commercialization. Successful effort on this project will result in increased renewable resource based power, reduction of GHG emissions, and establishment of a new power industry in Florida while helping the electrical utilities meet pending renewable portfolio standards. The project will be closely coordinated with FPL to support its planned 300MW solar thermal power plant. The project participants include recognized experts in Solar Thermal Power who have already developed the first generation design software for FPL.

Task 4. Si Photovoltaics from Low-cost, Florida-derived Si Feedstock

The PV industry is the fastest growing industry in the world. The rapid expansion has produced a demand for Si feedstock than now exceeds the demand of the IC industry resulting in the need for nearly $10B in added capacity. This Si feedstock shortage has caused the contract price of PV grade Si to exceed $50/kg and recent spot market prices in the ~$300/kg range. SRI has developed a technology to take a Florida phosphate industry by-product to electronic grade Si at a cost well below PV industry targets. The goal of this Task is to establish a Florida-based PV industry using this Si feedstock. This raw material to finished product PV industry would be a major boon to the State economy, estimated to be a multi-billion dollar industry, similar in size to Florida’s aerospace/defense industry. In addition, the number of indirect jobs created for a given investment in the PV industry (e.g., installation) is much greater than most industries. Further these jobs are high-value and there is tremendous export potential.

The largest US phosphate resources are in Polk County, FL, generating 32M tons of waste/year, and the resulting silicoflouride complexes (e.g., Na$_2$SiF$_6$) have little value. The SRI process converts Na$_2$SiF$_6$ to Si (product) and NaF (by-product used for toothpaste). Their process has been optimized to the extent that high purity, PV-grade silicon is produced and the estimated scaled production cost is ~$14/kg, well below the industry’s target price. The process has been demonstrated to 2 MT/yr and is now ready for scale-up. The next step is vertical integration of the process to PV module production. Although SRI has promising preliminary results on the electrical properties of Si ingots as well as fabricated cells, the influence of specific impurities on cell performance is not clear. This Task will direct research aimed at translation of this Si feedstock to high efficiency PV produced by this innovative process. We will generate performance data to guide SRI process improvement and assist qualification by potential PV producers. SRI will produce Si feedstock, cast ingots and characterize impurity content to verify initial quality. Wafers sliced from the ingots will be characterized for electronic properties
(resistivity, carrier type, lifetime, and diffusion length). We will fabricate PV cells from these wafers, characterize performance (open circuit voltage, short circuit current, fill factor, and efficiency) and compare with results from conventional cells. Similar comparisons will be made for interested cell manufactures using their specific process.

Additionally, the Consortium team will develop novel approaches to thin-film-Si PV using the phosphate-based industry feedstock. Thin-film-Si is motivated by cost reduction by substituting the Si substrate with a less expensive material so that only a thin ~25 µm Si layer is needed. Cell performance will be evaluated and material properties characterized. The Consortia will serve as the interface between the feedstock provider (SRI) and the PV manufacturer by determining the relationship between feedstock quality and device performance.

**Task 5. Florida Based Low Cost Manufacture of Photovoltaic (PV) Systems**

PV has entered into a period of record growth. While the US led early on, it lost the lead to Europe and Asia whose governments are aggressively pursuing solar and providing the economic climate for its growth and success. Over 27,000 new jobs were generated in Germany alone as a result of PV solar energy. Most of the current production is based on crystalline Si technology. However, there are fundamental limits to the ultimate Si costs that may inhibit it from achieving the desired level of contribution to worldwide energy production. In contrast, thin-film PV technology can reach the desired outcome due to fast deposition rates and lower cost. USF, UCF and UF play a lead role in developing these technologies. The world record 16% efficiency for CdTe was set by USF and held for 10 yrs. The time has come to coordinate the leading-edge resources within the SUS and establish a Florida PV industry.

To achieve the desired level of energy generation, efficiency has to be >13%, which has been achieved in the laboratory; however, there is an inability to transfer laboratory success into manufacturing success (Table 3). The transfer process has been the purview of industry, with limited success. What is needed is a fundamental understanding of this process, which can best be done in a university environment with industry cooperation. It is proposed to combine SUS expertise with local industry to develop this foundation. We will build and operate a pilot line that includes all aspects of module fabrication and characterization for the SUS/industry partners to develop manufacturing processes.

**Task 6. Advanced PV Device Program**

The US DOE Solar America Initiative (SAI) has an ambitious 50% efficiency goal. UCF, UF and USF are already participating in the SAI program: UCF is conducting research with BP Solar on reliability and durability, UF just won a solicitation for research on hybrid cells and USF just won a solicitation for research on next generation CdTe cells. However, this research represents only a small fraction of available support and the SUS should position itself to be more competitive in this federal R&D effort. Thus, the goal is to expand the SUS capabilities and infrastructure to conduct R&D toward the 50% efficiency goal, leveraging federal research dollars, creating valuable intellectual property and attracting major PV industries to the state. R&D will focus on hybrid organic PV, nano-architectures, multiple excitation generation, plasmonics, and tandem/multijunction cells.

**Task 7. PV Energy Conversion and System Integration**

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<th>Table 1: Thin film PV efficiency</th>
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This Task is an innovative system-driven approach for the design and commercialization of PV modules, representing a paradigm shift in the way solar energy is deployed and commercialized. The main target is to dramatically reduce PV cost through innovation and system integration to foster a new solar energy based industry, creating new R&D and manufacturing jobs in Florida.

The proposed PlugN’Gen system architecture allows PV modules to be produced and marketed just like other “plug and play” consumer products (e.g., TVs), overcoming the installation cost barrier. Today’s grid-tied PV systems use PV panels in series to produce high-voltage DC. Centralized inverters convert this to grid-compatible AC. High-voltage DC is hazardous requiring expensive installation (installed cost is 2X that of the PV panels). In contrast, PlugN’Gen modules have inverters on the back of each panel. Installation of these modules is far less costly, requiring no special training. The modularity of AC module systems allows optimized harvesting of available power and systems to be incrementally installed (thus more budget-friendly). Advanced inverter topologies will be investigated in order to achieve efficiency, reliability, and cost objectives. Inverter lifetime will be increased to match the PV panels they service. Digital control techniques will allow integration of control functions, implementation of complex algorithms in low-cost controller chips, and better response to temperature and solar insolation changes.

**Task 8. Integrated PV/Storage and PV/Storage/Lighting Systems**

To the consumer and utility it’s not the cost of PV, it is the availability (timing) and amortized cost of generated electricity that is critical. Unfortunately, the timing for peak solar power does not coincide with peak power demand and energy storage (battery) is necessary, thus the need for an integrated/optimized PV/battery system. Another aspect of this is to consider a primary end use of electric power, lighting. Light emitting diodes (LED), operating on low voltage DC, have 4X the efficiency of incandescent bulbs. Each PV panel generates low voltage DC; however, PV power must be converted to 110VAC for grid-distribution and then stepped down to low voltage DC for LED lighting. Major system efficiencies can be attained by the PV/battery/LED system since each is a low-voltage DC device.

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.

![Figure 4: From today’s centralized PV inverter to PlugN’Gen AC modules: a paradigm change.](image-url)

The goal is to design, integrate, verify, and demonstrate both photovoltaic power, hydrogen generation through electrolysis to stored hydrogen fuel cell systems and stored liquid biomass fuel to fuel cell systems that will vastly improve the reliability and durability of backup power for extended outages. The uninterrupted power supply (UPS) for telecom applications represents a unique market entry opportunity for Florida. Current UPS systems are not satisfactory because of capacity loss in hot environments, and with 1000s of communications towers throughout Florida there is high commercial potential. Moreover, 20% of Florida telephone customers rely on UPS for emergency and personnel communications after hurricane outages. Research will focus on the various components and systems demonstrations to prototype development.


Buildings account for ~84% of total electric power use in the state. A ~35% reduction in building energy use can be achieved by improved efficiency, saving Florida millions of kWhr/yr. The US DOE goal is to create efficient “zero energy homes” using only on-site PV power. Energy storage can be provided by PHEVs (Task 2). Using a systems approach to couple zero energy home technology with PHEVs offers the opportunity to develop marketable products that meet Florida’s energy and environmental goals. New and emerging building energy efficiency systems require study with respect to Florida’s unique hot/humid climate. Cost/benefit analysis of efficient buildings, building energy efficiency expertise in our education system and our marketplace along with creative financial instruments and business models are needed. To address this need we will: conduct field evaluations to document the cost/benefits of “beyond code” building energy efficiency programs; conduct testing of building efficiency options; create building energy course work; recruit advanced Florida builders and early adopter homeowners to collaborate on a zero energy home – PHEV design project; construct and monitor zero energy homes; develop optimization models, including benefit/cost analysis and grid interactions.

Task 11. Establishing an Efficient and Reliable Energy Delivery Infrastructure

All of the above systems interact with the grid and by optimization can be integrated to reduce our overall energy demand and increase grid resilience. In this Task we will use existing and planned communities as in-situ test beds to demonstrate integrated systems of revolutionary distributed green generation, improved grid and home efficiency, and automated energy conservation technologies for residential, substation, and distribution scale energy systems. Projected outcomes include: a 25% reduction in Florida’s electric generation growth needs; reduced power system outages and restoration times for Florida; a market for green building construction, with distributed grid connected renewable generation; reduce GHG emissions; a new green energy value dimension to Florida’s housing market, and ultimately Florida becoming a world leader in green community construction. We purpose to demonstrate advanced integrated energy generation, management, and utilization for substations, distribution, and modern residential and commercial developments, produce green distributed energy, reduce energy demand and improve security at the wide-area utility distribution level in Florida, and subsequently drastically reduce Florida’s GHG emissions. We will integrate three sub-systems: distribution level Renewable Energy Strategic Load Pockets; Intelligent Residential Energy Management Systems; and real-time transient analysis monitoring

Figure 5: Community-based energy system
Task 12. Carbon Capture and Sequestration

Current dependence on fossil fuels for US electric power and transportation fuels continues to increase GHG emissions resulting in global warming and climatic change. Cost-effective CO\textsubscript{2} removal is required to accommodate growth and bridge our transition to greater energy diversity and efficiency. Several carbon sequestration approaches are under development by our team utilizing abundant Florida resources. Geological sequestration by CO\textsubscript{2} injection into saline carbonate aquifers is being developed and tested by USF, representing a new sequestration technology. Biomass-based sequestration is being developed at UF using Florida crops and has widespread support of its agricultural industry. This will focus on a by-product of renewable fuel production as a carbon sink. Chemical sequestration to useful products is being developed by UCF via a novel catalytic process that includes solar-derived H\textsubscript{2}. The resulting elemental carbon and lignin-based polymers can be stored and transported at ambient temperatures and pressures, and stored in geologic formations or used as possible commercial products. Each approach offers unique advantages to offset our transition to more carbon neutral power and transportation. Cost-effective carbon capture and sequestration is of primary interest to the major Florida power companies. They have proposed formation of a state-wide consortium to address this issue and the proposed Consortium can serve this role. Florida agricultural industries are also very interested in developing carbon sequestration as a supplemental land use.

Task 13. Clean Drinking Water using Advanced Solar Energy Technologies

Availability of fresh water is one of the biggest problems facing the world and Florida is one of the most vulnerable to fresh water shortages. Moreover, Florida ground water is contaminated in many locations from leaky underground tanks, agricultural pesticides, and other chemicals. Although possible to desalinate abundant sea water, conventional systems are too energy intensive. Solar energy can provide the needed energy, and innovative new solar vacuum (USF) and humidification/dehumidification (UF) desalination systems can provide adequate fresh water for the state’s needs. Systems will be developed for both bulk water desalination and small community needs/disaster response. We will also develop photocatalytic disinfection to remove contaminants and integrate these technologies with solar PV for complete water supply systems.