University of South Florida

Clean Energy News

Summer 2014

Key Research Projects

- Environmentally clean energy systems
- Solar thermal power
- Photovoltaics
- Concentrating solar power
- Energy storage (phase change materials, thermal storage, batteries, supercapacitors)
- Photocatalytic detoxification/ disinfection technologies
- Hydrogen production and solid state storage
- New efficient thermodynamic cycles
- Solar energy conversion via rectifying antennae
- Biomass conversion/biofuels

CERC
Clean Energy Research Center
University of South Florida

Concentrating Solar Thermal Power Plant

To reduce the cost of energy storage, major efforts are being directed towards the use of encapsulated phase change materials to be incorporated in concentrating solar power (CSP) plants to increase the capacity factor and address utility load requirements. Being able to save the energy collected from the sun, is a game changer, and phase change materials are seen as the next frontier in solar and other renewable energy.

With funding from federal and private industries, the CERC has built a CSP plant on the USF/Tampa campus. This concentrating solar thermal pilot power plant can produce 50 kW of electricity. The collected solar energy is translated into thermal heat which is stored in phase change materials, which are also under development at the CERC. The plant will be used for continued research and student hands-on education.

Low Cost Novel Smart Material

CERC desearchers have developed a low cost novel smart material that changes color rapidly without any external energy stimulus. Windows are responsible for 30% of the heating and cooling loads in buildings. Thin film coatings on glass with color change capabilities would reduce energy consumption by reflecting unwanted radiation and transmitting needed radiation during daylight hours. Currently, available chromic windows cost \$15/ft^2 with an additional \$5/ ft^2 to \$10/ ft^2 for periodic maintenance. Due to high costs, smart windows using electrochromic, liquid crystal, and photochromic technologies have not been commercially popular. It is estimated that the market for smart glass will grow at a rate of 30% annually therefore an opportunity exists for a company that can produce a chromatic device that is both effective and less expensive.

Phase Change Materials

Currently, CSP power plants use sensible heat storage systems based on synthetic oil or molten salts, which need large amounts of materials and therefore large tanks making the systems very expensive. Use of phase change materials (PCMs) provides the advantage of much larger specific storage capacity reducing the cost of the material and the storage tanks. PCMs have some drawbacks, most important of which are low thermal conductivity, and large volume changes during phase transition. Moreover, some PCMs, such as salts, are highly corrosive, especially at high temperatures. One of the promising ways to solve these problems is to encapsulate the PCM and use it in a packed bed heat exchanger. Macro-encapsulation of the PCM also helps in the separation of the PCM from other fluids where needed, increases the heat transfer rate by improving the surface area to volume ratio and provides a self-supporting structure for the PCM in molten state. We have introduced a number of innovations resulting in macro capsules of PCMs that take care of all of these concerns. The goal is high temperature thermal storage for power plant application by developing very high temperature (300-1000°C) thermal storage in PCM contained in ceramic or metal preformed structures. These salt filled balls can turn water into steam which powers turbines producing electricity.

FLEX House

The FLEX House is a flexible, modular building system that can adapt easily to different site situations and plan configurations. It is designed for a hot, humid climate with intense solar radiation throughout the year. A photovoltaic array provides just enough electricity to reach net zero energy performance. A solar thermal system provides hot water and reduces the energy consumption of the heat pump. A solar thermal integrated mini-split heat pump will heat or cool a reservoir and circulate cold or hot water to ceiling fan units. The FLEX House systems are continually under re-envisioning. It is used as a teaching device for students in engineering, architecture, and sustainable energy use.

Photocatalytic Detoxification

Chemical, microbial and particulate matter contamination of air and water poses an increasing challenge. CERC has long researched many iterations of photocatalytic detoxification and disinfection. Photocatalytic oxidation is a process where a semiconductor upon adsorption of a photon, acts as a catalyst in producing reactive radicals, mainly hydroxyl radicals, which in turn can oxidize organic compounds and totally mineralize them. This way organic molecules are decomposed to form carbon dioxide, water and mineral acids as final products When used in combination with solar radiation, titanium dioxide (TiO_2) infused filters captures and oxidizes volatile organic compounds, bacteria, spores, dust mite allergens, molds, endotoxins and viruses .

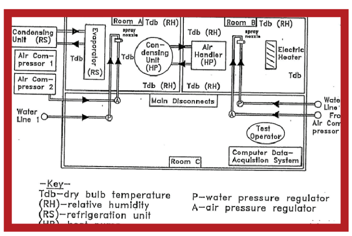
A titanium dioxide (TIO_2) infused filter is inserted into an experimental closed loop air duct.

Supercapacitors and Rectifying Antennae ("Rectenna")

Though conceived nearly 40 years ago, rectennae are still a work in progress. Developing a MIMs rectenna, nanotenna and rectifier (diode) that can operate at the 30 GHz range, is the goal of CERC research. A rectenna is used at the receiving end of wireless energy transfer. CERC is actively developing super-capacitors with energy densities close to those of electrochemical batteries which in addition to superior power densities produces superior batteries. It employs an appropriately sized antenna element to couple with the electromagnetic energy source and pass high frequency AC signal. From there, the AC signal is rectified typically through the use of a high speed Schottky diode—thus creating useful DC output.

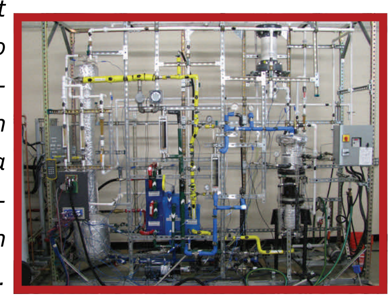
AC Testing Laboratory

Using a specially constructed AC test laboratory, the CERC (using ASHRAE Standard 37) is currently investigating a specific organic Rankine power cycle (ORC) to determine the cooling and heating capacities of unitary AC and heat pump equipment. This specialized lab can test various AC technologies. The lab consists of two separate environmentally controlled insulated rooms. Temperature and humidity controls including a secondary air-conditioning system are provided to allow outdoor atmospheric conditions to be simulated, maintaining ASHRAE set condition (outside 95F DBT/75F WBT; inside 80F DBT/67F WBT). The lab is fully instrumented to record all operating variables (humidity, pressure, dry and wet bulb temperatures, and consumption).



Waste Heat Capture

Developed by Prof. Yogi Goswami, the "Goswami Cycle" recovers waste heat and translates it into electricity. It is a novel thermodynamic cycle that uses a binary mixture to produce power and refrigeration simultaneously in one loop. This cycle is a combination of the Rankine power cycle and an absorption cooling cycle. Its advantages include the production of power and cooling in the same cycle, the design flexibility to produce any combination of power and refrigeration, the efficient conversion of moderate temperature heat sources, and the possibility of improved resource utilization compared to separate power and cooling systems.



Field Testing of Gas Heat Pumps

To evaluate the emerging natural gas-based technologies, CERC has implemented field testing of gas heat pump (GHP) systems in public buildings in DeBary, Plant City and Santa Rosa Beach, FL. The GHPs are equipped with live data capturing by a remote data logging system that captures the temperatures, pressures and other operating parameters of the outdoor and indoor units. A refrigerant flow meter was required to measure the actual heat removal or heat pumping rate by the GHP units. Additionally temperature and humidity sensors and natural gas flow meters are tied into data acquisition systems. The research is ongoing.

Natural gas consumption meter.

Refrigerant flow meters wired and connected to data logger system.

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Clean Energy is Green Energy

Florida has no substantial indigenous supply of fossil fuels but we do have solar and biomass resources. The Clean Energy Research Center (CERC) at the University of South Florida pursues R+D of new/ environmentally clean energy systems, such as, solar thermal power, photovoltaics, concentrating solar power, energy storage (phase change materials, thermal storage, batteries, supercapacitors), photo-catalytic detoxification/disinfection technologies, hydrogen production and solid state storage, new efficient thermodynamic cycles, solar energy conversion/rectifying antenna (rectenna), and biomass conversion/biofuels. **http://cerc.eng.usf.edu/**

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Student Activities

Poster Winners: Two of CERC's Ph.D. candidates won prizes for best poster at the 2014 USF Research One, an event which showcases excellence in graduate student research. Alam and Sharma each won $500 in travel funds.

Tanvir Alam, Jaspreet Dhau, and Yogi Goswami: "Encapsulating Phase Change Materials: Application in Thermal Energy Storage for Concentrating Solar Power Plants."

Saumya Sharma, Elias K. Stefanakos, J. Zhou, and Yogi Goswami: "Narrowband Infrared Emitter for Energy Harvesting Applications."

Student Group: In 2014, CERC graduate students formed " ISES POWER at USF" a student group of the Int'l Solar Energy Society, to educate and pursue solar energy interest campus- and community-wide. They earned USF's "Outstanding New Student Organization" recognizing the group's rapid growth and its ongoing outreach .

Solar Award: Rachana Vidhi, CERC Ph.D. Candidate, was awarded the American Solar Energy Society's (ASES) John and Barbara Yellott Award (2014) for her work on supercritical Rankine cycles for low temperature power generation.

Solar Scholarship Winner: Jamie Trahan, CERC Ph.D. candidate, was honored as the first recipient of the "Johnnny Weiss Scholarship" from Solar Energy International, who's empowering mission is to teach sustainable energy practices. The scholarship gave Trahan the opportunity to take hands-on-training in photovoltaic systems in Paonia, Colorado, in June.

Faculty Activities

Yogi Goswami

- Fellow, American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE), 2013.
- Technical Communities Globalization Medal, (ASME) 2013.
- Srinivasan, S., Niemann, M.U., **Goswami, D.Y., and Stefanakos, E.K.** (2013) "Method of Generating Hydrogen-Storing Hydride Complexes", US Patent number 8,440100 (May 14, 2013).
- Int'l Scientific Committee, Solar World Congress 2013, ISES, Cancún, México.
- Int'l Scientific Committee, SolarPACES Conference, IEA, Las Vegas, NV, 2013.

Elias K. Stefanakos

- Editor-in-Chief, *Journal of Power and Energy Engineering*, Scientific Research Publishing. (2014)
- Editorial Board Member, *The Scientific World Journal*, Hindawi Publishing Corp.
- Int'l Scientific Committee, Solar World Congress 2013, ISES, Cancún, México.