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

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 the Florida Energy Systems Consortium (FESC), 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

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. Smart windows development using electrochomic, liquid crystal, and photochromic technologies is still relatively new.

CERC researchers have developed a low cost novel smart material that changes color rapidly without any external energy stimulus. In one application the material is opaque under normal conditions. When contacted with a certain metal, it becomes transparent in seconds. The patent pending technology can be used for commercial, residential and transportation window applications and optical filters, and electronic devices.

The market for smart glass may grow at a rate of 30% annually creating an opportunity for successful commercialization.

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.

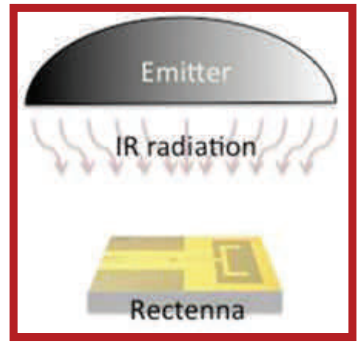
Photocatalytic Detoxification

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")

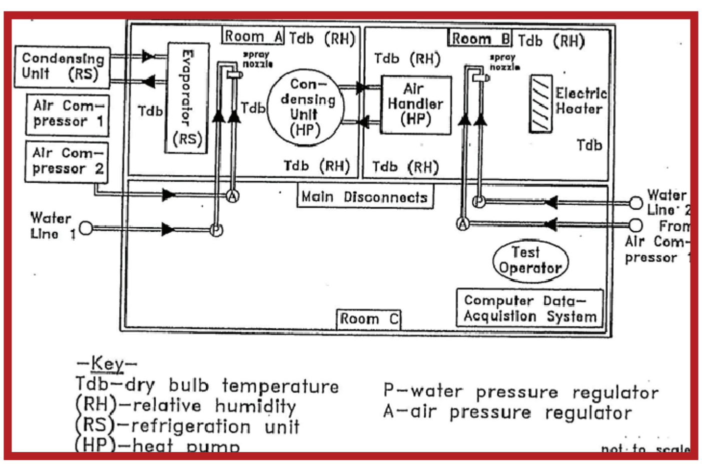
Though conceived nearly 40 years ago, rectennae are still a work in progress. Developing a rectenna, nano-antenna and rectifier (diode), that can operate at the 30 GHz range, is the goal of CERC research. A rectenna is used at the receiving end of wireless energy transfer. Advanced polymers, nano-meter thin layers and asymmetric super capacitor configurations are also being researched at CERC. The main goal is to develop super-capacitors with high energy densities and low self discharge.



ASHRAE Standard Facility

A specially constructed AC test laboratory is being developed at CERC (using ASHRAE Standard 37). This specialized lab can test various air conditioning 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 conditions (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).

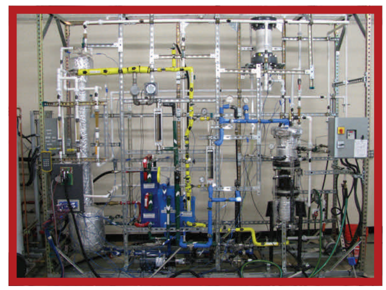
Using this ASHRAE Standard testing lab, CERC is currently investigating a specific organic Rankine power cycle (ORC) to determine the cooling and heating capacities of unitary AC and heat pump equipment.



CERC's ASHRAE Standard test facility on the University of South Florida

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.

Clean Energy is Green Energy

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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. *See our website for a complete listing of our research, patents and publications:* http://cerc.eng.usf.edu/

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Exciting International Projects

ICELAND "PCM for Geothermal Heat" — To study industrial scale use, storage and transport of thermal energy from geothermal and other heat sources in the form of PCM for heating and cooling of housing, and district heating systems and to determine suitability of full scale power plants and transport systems.

INDIA "SERIIUS" — The objective of the Solar Energy Research Institute for India and the United States (SERIIUS) is to develop low cost utility scale thermal energy storage for next generation concentrating solar power plants and reducing cost/watt of delivered solar electricity through dramatic improvements in conversion efficiency and accelerating the introduction of new concepts and architectures in solar-energy technologies and production.

SOUTH AFRICA "Cool Cities" — Accelerating the Deployment of Energy Efficiency and Renewable Energy Technologies in South Africa Training curricula development for RE technologies and support LBNL on EE technologies. Capacity building workshops for RE technologies. Measurement and modeling of RE technology impacts.

Solar Energy Courses

- ECH 2217: Energy, Environment and Sustainability: Students learn to analyze innovative energy systems and technologies that support sustainable energy use, energy security, and environmental harmony for life on Earth.
- ECH 5931: Solar Energy Fundamentals and Applications: Designed to teach students to estimate solar radiation on any surface and to design solar energy components, subsystems and systems for various solar energy applications. Knowledge of heat transfer, fluid dynamics and thermodynamics would be helpful but is not required.
- ECH 6931/EEL 6936: Design of Solar Power Plants: Acquire knowledge and tools to design Photovoltaic (PV) and Concentrated Solar Power (CSP) power plants. **Prerequisite:** ECH 5931 Solar Energy Fundamentals and Application or equivalent.
- EEL 6935 Power Market: Students will learn about renewable energy power delivery and smart grids.

TECHNOLOGIES READY FOR COMMERCIALIZATION

♦ ***Materials and Methods of Encapsulation of Phase Change Material:*** *Allows storage of large amounts of heat in small volumes reducing the cost of storage tanks and equipment.*

♦ ***Method of Encapsulating a Phase Change Material with a Metal Oxide:*** *Encapsulating PCMs in metal oxide allows high cyclic performance up to 500 °C.*

♦ ***Low Cost Novel Smart Material:*** *Useful for window applications and optical filters; toys, electronic devices, and display products.*