Energy Research at Clarkson University

Bioenergy (A Andreescu; P. Christiansen, S.Grimberg, R.Jachuck, R.Partch, S.Powers, S. Rogers, E.Thacher, R.Welsh,)

The conversion of biomass and organic waste into biofuels, including biogas, fuel oil, solid fuel and gasoline and the associated environmental impacts and social consequences is at the center of this research area. The abundance of biomass feedstocks in Northern New York and their potential to enhance regional economic development are substantial. The scope of research ranges from the conversion of biomass to fuels using thermo-chemical and biological means, to sociology research to investigate the cause of farmers' reluctance to adopt new energy technologies, such as anaerobic digestion, even when they provide economic benefits. Funding is for this research area has been provided by NYSERDA, NY Ag & Markets, NYSTAR, USDA, and DOE. Collaborations with area farmers and Breyers Yogurt, Inc, a local dairy processing plant, have been established to transfer research results to energy consumers/generators.

Energy Education (S.Powers, K.Visser)

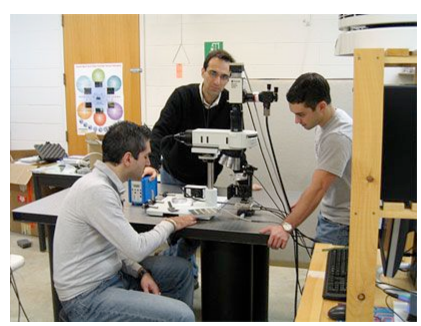
Increasing the literacy of the general public on energy-related matters is critically important to promote conservation and efficiency and to ease the adoption of new energy technologies. Energy education activities range from middle school through PhD levels. K-12 outreach has included the development and implementation of units on alternative energy (8^{th} grade) and the hydrogen/biofuel economy (high school). These units have been taught by our own graduate students in partnership with local teachers. STEM workshops to educate the teachers themselves about energy have also been established. Scholarly research is ongoing to measure energy literacy among our students and assess the effectiveness of various curricular programs. These educational initiatives have been funded by the NSF and NYSED.

Energy Efficiency (C. Cetinkaya; R. Jachuck, B.Helenbrook, R.Partch, E.Thacher, K.Visser)

The efficient use of energy, whether in copy machines or transportation vehicles, is critical to reducing costs and emissions. Energy efficiency is an economic resource and can be thought of as an alternate "fuel." For every watt of power saved in an end use appliance, approximately 6 watts of power is saved at a coal-fired power station, along with the reductions in emissions associated with that power generation. Current projects include NYSERDA projects on the reduction of drag in trucks to improve fuel economy and the recovery of exhaust heat from trucks to generate power for vehicle use and a NYSTAR-Xerox project on thermal diffusion roller efficiency in copy machines.

Energy Harvesting and Storage (C.Cetinkaya, W. Ding, E.Sazonov)

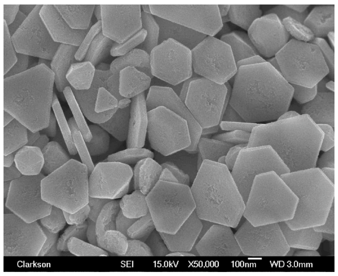
As device sizes keep shrinking, the power requirement of the devices has been decreasing. In recent years, a trend to harvest energy from the environment rather than to use energy from a generator, power line or battery has been developing. Almost all the systems are subjected to various types of transient and vibrational excitations from the environment. In many cases, the level of vibrations would be sufficient to generate sufficient amounts of energy to drive piezoelectric motors and wireless communication devices. Faculty in this research group, are collaborating with Cornell University faculty in the development of an array of self-tuning mechanical oscillators to be fabricated using MEMS technology and a project funded by the Transportation Research Board on the design and development of a generator using bridge vibrations to supply power to sensors for bridge monitoring is underway.



Environmental Impacts of Energy Systems (S.Dhaniyala, A.Ferro, T. Holsen, P. Hopke, S. Powers, S.Rogers, A. Rossner)

Researchers have estimated that over 80% of our global air pollution arises from our energy systems. Researchers at Clarkson's Center for Air Resources Engineering and Science have been measuring and modeling emissions, downwind concentrations, and human exposure to transportation and power production energy systems for many years. Other researchers are working to estimate the overall environmental impacts at various stages of the energy extraction, production and use stages of the energy lifecycle. This research has numerous collaborators and has included funding by the EPA, NYSERDA, USDA, NREL and others.

Fuel Cells and Hydrogen Fuel (C.Cetinkaya, D.Goia, R.Rengaswamy, I.Suni)

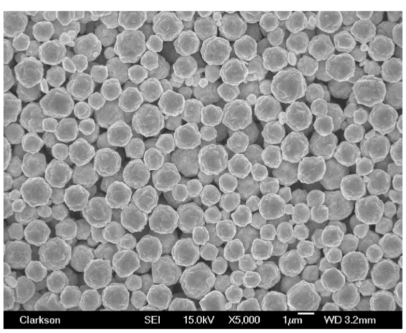


The adoption of hydrogen for fuel cells will require a major infrastructure investment in a relatively short period of time. Extreme reactivity of hydrogen is recognized as a serious risk factor. Hydrogen safety is very different from gasoline safety due its gaseous state which leads to different modes of propagation. For safe transportation, distribution and delivery, the hydrogen infrastructure must be monitored in real time. A MEMS sensor platform is being developed at Clarkson in collaboration with Cornell University to sense hydrogen concentrations and pressures for safety and storage needs. Other projects include modeling and optimization of industrial solid oxide fuel cells, use of supercapacitors for improving the transient response of fuel cells and incorporation of new nano materials for both solid oxide fuel cells (SOFCs) and proton exchange membrane fuel cells (PEMFCs).

Power Systems (D.Aidun, P.Marzocca, P.McGrath, T.Ortmeyer)

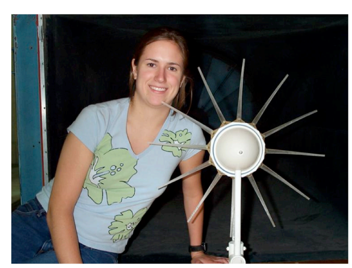
The integration of intermittent renewable energy sources, such as solar and wind, into the existing power grid present is particularly challenging. While a portion of this electricity is used in the stand-alone applications, much of this electricity is fed into the electric power grid. Efforts are underway to identify the benefits that distributed energy resources provide to grid operation, such as loss reduction and capacity deferment. Clarkson's High Voltage Laboratory's accelerated life testing capability is used to improve grid reliability. Recent support comes from NYSERDA and GE Energy Systems to develop accelerated life assessment tools for testing reliability and life assessment of complex industrial settings. It is hoped that tools for utility designers to maximize the reliability benefits of their upgrades, help identify critical or significant design or process characteristics that require special controls to prevent or detect failure modes, will de determined.

Solar Energy Systems (S.Babu, D.Goia, E.Katz, S.Minko, D.Shipp, I.Sokolov)



While silicon-based photovoltaic (PV) devices have been the most widely used to date, their cost has led to significant interest in organic and organic-inorganic hybrid materials for use in PV devices. Such materials include various conducting polymers, quantum dots and semiconducting oxides, all of which have great potential for application in photo- and electrochemical devices (e.g. solar cells, sensors). In particular, PV systems based on materials that have well-ordered nanoscale features are highly sought after because they may increase efficiency through both improved charge separation and reduced excitation (positive and negative charge pairs) recombination. Current work is centered on creating potential low-cost, large-area PV devices through the use of well-ordered polymer nanocomposites. This should improve efficiency and enable devices that will be very thin and can be printed onto flexible substrates. Work through Clarkson's Center for Advanced Materials Processing, collaborations with RPI and Corning Inc. and support from NYSERDA are helping to facilitate the work.

Wind Energy (G.Ahmadi, D.Bohl, E. Bollt, B.Helenbrook, P.Marzocca, D.Valentine, K.Visser)



Over 30 years ago Clarkson was conducting research in the use of vertical axis wind turbines as a source of local, rural energy. Today, researchers continue to investigate efficient strategies of extracting energy from the wind. The current research focus is on small turbines in the 1-100kW range, suitable for rural, residential and commercial applications. Several of the concepts utilize novel blade concepts to improve efficiency, reduce noise and enhance the low wind speed performance. Clarkson also tests small turbine prototypes at the Wind Turbine Test site in Potsdam. Future Energy Solutions of NY and Optiwind from CT are presently funding new design concepts, including a large scale turbine for commercial use.