Introduction to Completed Project Reports

Eight GCEP research projects have reached completion during the past year in the areas of Hydrogen Production, Distribution and Use, Renewable Energy-Solar, and Renewable Energy-Biomass, CO_2 Capture and Separation, CO_2 Storage, Advanced Combustion, Advanced Materials and Catalysts, and Integrated Assessment of Technology Options.

In the area of solar energy, Professor Peumans of Stanford University completed a project on molecular solar cells. During his three-year research effort, the author developed organic photovoltaics (OPVs) based on intrinsically stable conjugated molecules, with the goal of addressing the durability issue of this class of devices. From a conversion efficiency standpoint, photocurrent was enhanced by increasing the absorptivity of the small molecules in the visible and near IR spectra. Also, exciton diffusion and charge transport were greatly enhanced by using various deposition and post-treatment techniques that allowed for the structural engineering of self-assembled bulk heterojunctions architectures.

In the area of renewable energy biomass, Professor Khosla completed a three year project on Microbial Synthesis of Biodiesel. The goal of this GCEP-sponsored project was to develop a fundamentally novel and practically useful fuel derived via a microbial fermentation route. Specifically, the researchers engineered the most well understood organism in biology, Escherichia coli, into a microbial factory for overproduction of biodiesel.

In the area of carbon storage, a team led by Professor Jerry Harris, with members from both Geophysics and Energy Resources Engineering, investigated carbon dioxide sequestration in geological porous media, particularly unmineable coal seams. Their fundamental work is interdisciplinary with the tasks divided into site assessment, prediction and monitoring activities.

In the area of advanced materials and catalysts two projects were completed this year. Professor Paul McIntyre and Professor Shriram Ramanathan of Harvard University explored new approaches for low-to-intermediate temperature solid oxide fuel cells (SOFCs) using nanoscale-engineered metal-oxide electrolytes manufactured by atomic layer deposition. They also exploited photo-excitation effects to reduce the activation energy of the reactions occurring at the membrane surface.

Professors Dave Goodwin and Sossina Haile of the California Institute of Technology combined advanced materials with advanced nano- and micro-scale fabrication methods to build high-performance, low operation-temperature solid oxide fuel cells (SOFCs). Their approach consisted of engineering the SOFC system as a whole: the physical structure of the anode, cathode and electrolyte along with the chemical structures of all three components. Materials considered included ceria for the electrolyte and the anode, and the advanced perovskite, BSCF, for the cathode.

In the area of Advanced Transportation, one project by Cui and Prinz reached completion. Professors Yi Cui and Fritz Prinz's project was aimed at developing high-energy-density electrodes for lithium ion batteries for electric vehicles. Close-packed, core-shell nanowire electrode architectures were investigated as a means for using low-cost and high specific energy electrode materials – such as silicon and germanium – that would suffer from poor stability in other configurations.