Introduction to Advanced Materials and Catalysts

The development and advancement of materials is an overarching need in systems that extract, distribute, store or use energy. The performance of these systems depends on the properties of the materials: plastics, coatings, alloys and catalysts are some of the broad classes of materials used in current energy devices. Advancements in these materials optimize energy conversion processes, improve system efficiency, extend lifetime, and reduce CO_2 emissions. Although initially developed for a specific application, material properties may crosscut to other energy technologies or industries.

GCEP has several projects whose main focus is on materials development. Most of these are officially listed under their application area. Some projects have a materials component to their research. For example, research in the Hydrogen area includes studies of nanomaterials for hydrogen storage and NMR studies of fuel cell electrolytes. Studies in the CO_2 Separation and Capture area on advanced membrane reactors and development of innovative gas separation membranes involve development of materials with highly specific properties. The Solar area is replete with materials research for nanostructured photovoltaic cells. The studies listed above are all materials intensive investigations whose details can be found under their specific application areas in this report. In addition to these two projects came to an end this year, one led by Professor Paul McIntyre and the other by Professors Dave Goodwin and Sossina Haile, and are included in the final reports section. The remainder of this section is dedicated to the two currently ongoing investigation efforts:

Professors Robert Waymouth, Christopher Chidsey, and Daniel Stack are extending their previous work on novel organometallic catalysts for the purpose of efficient hydrocarbon conversion. Here they are developing new classes of molecular electrocatalysts for the efficient oxidation of chemical fuels. A novel click chemistry method is investigated to covalently attach the catalysts on a variety of functionalized carbonaceous and metal oxide electrodes.

Professors Thomas Jaramillo and Jens Norskov of Stanford University are developing solid-state electrocatalysts based on design principles from nature. They are exploring catalyst materials for two energy conversion reactions of interest; the electrochemical reduction of CO_2 and the electro-oxidation of water. The goal is to develop efficient energy storage devices based on liquid fuels that could potentially be coupled to intermittent renewable energy sources.