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 cross-cut 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. Studies in the CO_2 Separation and Capture area on the development of innovative gas separation membranes involve preparation and testing 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 are underway in the advanced materials and catalysts area. 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 based on chemical fuels.

Professors Roger Howe, Jens Norskov and Piero Pianetta are using first-principles simulations to discover materials with ultra-low work functions for energy conversion applications.