## Introduction to Energy Systems Analysis

GCEP's energy systems analysis research examines the impact of large-scale deployment of various energy technologies using net energy analysis. This technique combines fundamental energy analysis of a resource or device with evaluation of the wider technological system. Net energy analysis rigorously and systematically examines the energy return on investment of various technology options. It can provide guidance to laboratory researchers by identifying which parameters most impact a technology's energy performance and provide insight to project planners and policymakers by highlighting which technology choices make the most efficient use of energy resources.

Professor Sally Benson is leading the GCEP efforts in this area and over the past year has focused on two major thrusts. The first was a new framework to evaluate the maximum possible climate benefits of renewable fuel technology concepts that use $CO_2$ as a feedstock to produce liquid fuels. A key focus of this effort is to quantify how specific technical improvements (such as increased catalyst efficiency) will affect the ultimate climate impacts of an energy system (in terms of reduced $CO_2$ emissions). A prospective life cycle assessment model was developed to estimate the life cycle $CO_2$ emissions for a synthetic fuel production pathway, and it was applied to evaluate one of GCEP's own research projects in electrochemistry. The model can be applied to a wide range of technology scenarios for producing fuels from $CO_2$ (various process technologies and fuel products).

The second major thrust was a detailed comparison of battery electric vehicles and fuel cell vehicles in a combined economic and emissions analysis. This analysis extends beyond existing analyses by exploring how these two advanced vehicle options would interact with stationary energy infrastructure, such as energy storage and photovoltaic electricity generation.