Introduction

The GCEP research portfolio continued to evolve during FY 2006-07 as programs were funded in new and existing topic areas, and other research efforts came to an end. This technical report contains updates of the research activities currently funded and recently completed.

Progress made in current research activities funded by GCEP is described by topic area in Chapter 2. Investigators provide specific progress reports that include background, methodology, results, publications, and future directions. Chapter 3 contains reports on completed GCEP research efforts. In the past year, major research programs were completed in the areas of hydrogen, CO_2 storage, advanced combustion, and integrated assessment.

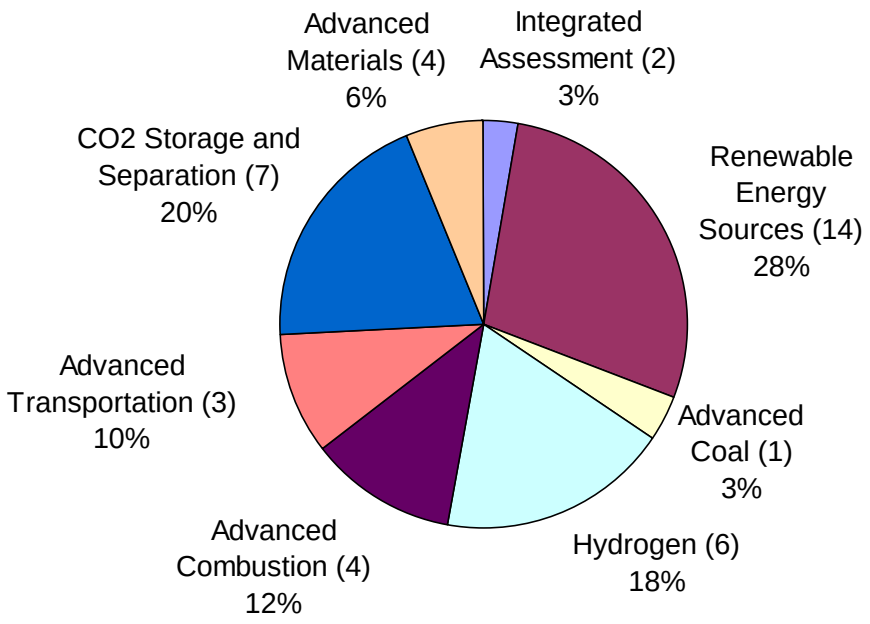
GCEP exploratory research continues to grow and attract interest. The purpose of this program is to allow exploration of new ideas by supporting preliminary research or analysis. These scoping research activities are limited to $100K and a one year performance period. Chapter 4 describes the five new exploratory efforts that are currently active.

Analysis activities to enable the quantitative comparisons of energy technologies conducted by the GCEP systems analysis staff are discussed in Chapter 5.

New research programs in advanced coal and advanced transportation began in FY 2006-07, which expanded the GCEP research portfolio to include the ten broad topic areas shown below:

1. Hydrogen production, storage and use
2. Solar energy
3. Biomass energy
4. Carbon sequestration
5. Carbon capture and storage
6. Advanced combustion
7. Advanced coal
8. Advanced materials and catalysts
9. Advanced transportation
10. Integrated Assessment of Technology Options

The distribution of approximately $61 million in approved funds across the research portfolio since the beginning of the Project is shown in Fig. 1. Significant GCEP support is provided to research in the areas of renewable energy, carbon capture and storage, and hydrogen. As the GCEP portfolio develops over time, we anticipate that GCEP research will expand across other aspects of energy systems.



GCEP Research Portfolio by Funding Distribution (~$61M Total)
Number in parenthesis indicates the total number of authorized and conditionally approved research programs within a topic area

While not an exhaustive list, technologies in each of these areas are expected to play important and interconnected roles in future energy systems and the reduction of greenhouse gas emissions (GHG).

Hydrogen has been identified as a potential energy carrier in some energy scenarios. At the present time, hydrogen is produced primarily from fossil fuels. Reduction of GHG emissions from this method of producing hydrogen would also require CO_2 capture and storage, another topic considered in this report. Current GCEP research activities in this area described here include work on hydrogen storage as well as on hydrogen production by microbes.

Solar and biomass energy are renewable energy options that have the potential for zero or low net emissions of CO_2. In particular biomass resources are being considered as potential alternative transportation fuels. Research in renewable energy still needs to address issues of cost, intermittency, conversion efficiency, and energy density. GCEP research in these areas involves investigation of fundamental processes in both organic and inorganic nano-structured solar cells, capture of electrical charge from biological organisms, and enhancement of both the yields and range of potential fuels from biomass.

Combustion is currently, by far, the most common first step in converting the energy stored in chemical bonds to energy services for humankind. Because of its ubiquitous nature and its intimate coupling with carbon-based fuels, even small improvements in combustion technology can have significant impact on total greenhouse gas emissions

whether they are from biomass or fossil resources. GCEP research in this area focuses on exploring combustion processes with novel fuels and engine designs.

Coal-fired power plants release considerable quantities of CO_2 into the atmosphere. Advanced coal research supported by GCEP addresses the integration of CO_2 capture and storage with increased combustion efficiency.

If the CO_2 produced from the conversion of fossil fuels is captured and stored, then a fraction of anthropogenic CO_2 emissions can be avoided. Fossil fuel combustion not only produces CO_2 but also a mix of other gases. Since the storage of CO_2 in the subsurface requires a relatively pure stream, CO_2 separation technology must be added to fossil fuel conversion systems. GCEP research on these topics addresses novel membranes and reactor designs for carbon separation, and improved understanding of the geologic settings, such as depleted oil and gas reservoirs, deep saline aquifers, and coal beds, that may be considered for CO_2 storage.

The development of advanced materials and catalysts is an encompassing need in systems that extract, distribute, store or use energy. GCEP research in this area is primarily focused on novel approaches to fuel cell design and operation that may lead to improved system efficiency and energy conversion processes, and reduced CO_2 emissions.

Reductions in transportation sector emissions require alternative fuels or electricity produced with low net greenhouse gas emissions. One option for using electricity in transportation is reversible storage in a battery. Research initiated by GCEP during the past year in batteries addresses low energy density, short cycle and calendar lifetimes, and high cost.

Energy systems analysis provides a tool for understanding the potential efficiency gains that may be achieved through GCEP research. GCEP systems staff have traced the flow of exergy and carbon through the natural and human systems. This evaluation reveals the major destructions of exergy, the exergy efficiency of human energy processes, and the processes most associated with atmospheric carbon emissions.