Introduction

As GCEP reaches a 5-year milestone, the 2007-2008 portfolio continued to grow in the number of new, completed, and ongoing programs spanning ten topic areas. This technical report contains updates from over 30 currently funded research activities and six from completed programs. Summaries from exploratory programs and internal analysis activities are also provided in the report.

Progress reports from current GCEP funded research activities are described by topic area in Chapter 2. Investigators provide updates that include a summary abstract, background, methodology, results, publications, and future directions. Chapter 3 contains reports from completed GCEP research efforts. In 2007-2008, major programs were completed in the areas of hydrogen and renewable energy (solar and biomass).

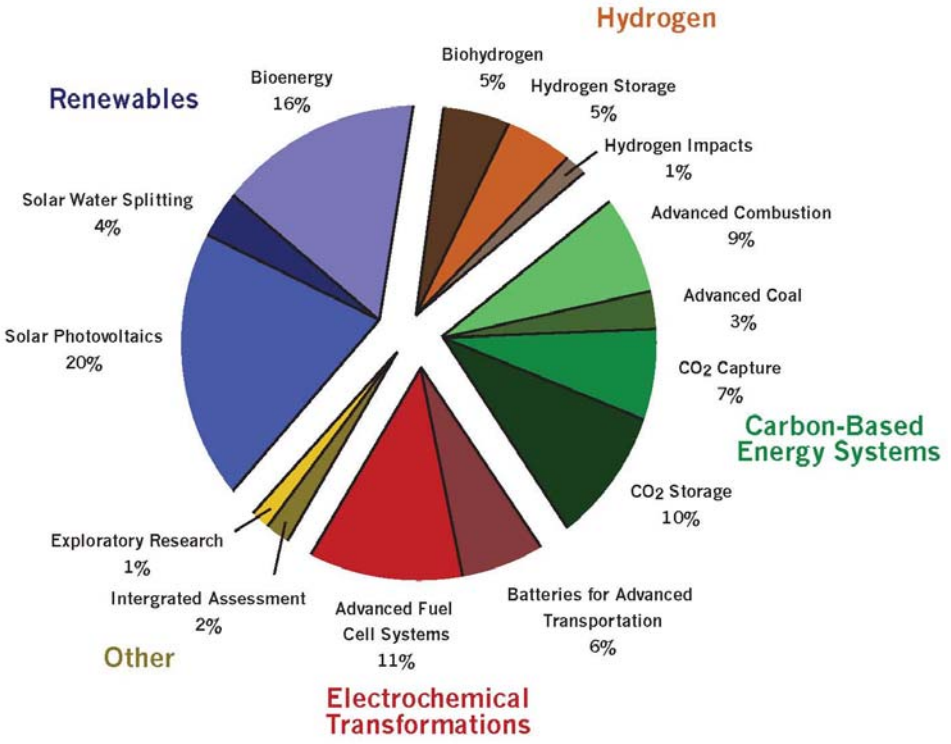
The exploratory research program continues to draw interest and has led to several fully-funded research programs. The purpose of this program is to allow exploration of new ideas by supporting preliminary research or analysis. These scoping research activities are limited to $100K and a one year performance period. Chapter 4 describes the six programs active for 2007-2008.

Research and analysis activities conducted by the GCEP systems analysis staff are discussed in Chapter 5. The analysis staff builds tools and analysis that enable the quantitative comparisons of energy technologies. In order to provide context for analysis activities, 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.

New programs in high-efficiency photovoltaics began in 2007-2008 and provided depth to the solar area. Additionally GCEP funded new and existing research across ten topics areas of the research portfolio shown below.

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

The distribution of approved funds across the research portfolio is shown in Fig. 1. There is strong support for research in renewable energy sources, carbon capture and storage. As the GCEP portfolio develops over time, the research will expand and cover other aspects of various energy conversions.



GCEP Research Portfolio by Funding Distribution

While not an exhaustive list, each of these areas is expected to play an important and interconnected role in future energy systems and the reduction of greenhouse gas emissions (GHG). For example, hydrogen has been identified as a potential energy carrier in some energy scenarios. The research portfolio described here includes work on hydrogen storage as well as hydrogen production by microbes. Currently hydrogen is produced primarily from fossil fuels. Reduction of GHG emissions from that method of producing hydrogen would also require CO_2 capture and storage, another topic considered in this report.

Solar radiation is the largest energy flow entering the ecosystem, representing an enormous resource of renewable energy that could potentially meet a large fraction of global energy needs. Several new solar programs are focused on developing innovative concepts for high-performance photovoltaics to improve efficiency, materials, cost, and durability.

Biomass energy is another renewable energy option that has the potential of low net emissions of CO_2. Biomass resources are being considered as potential alternative transportation fuels. Biomass research, like other renewable energy technologies, still needs to address issues of cost, conversion efficiency, and energy density.

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 to combustion technology can have significant impact on total greenhouse gas emissions whether they are from biomass or fossil resources.

Coal-fired power plants release considerable concentrations of CO_2 into the atmosphere. Advanced coal research integrates CO_2 capture and storage with increased combustion efficiency. System integration, material development, coal chemistry and conversion are areas with research needs.

If the CO_2 produced from the conversion of fossil fuels is captured and stored, 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 integrated into fossil fuel conversion systems. Furthermore, the capture system and storage reservoir should be located nearby to optimize the coupling of the processes. The primary geologic settings that have been considered for CO_2 storage are depleted oil and gas reservoirs, deep saline aquifers, and coal beds.

The development and advancement of materials is an encompassing need in systems that extract, distribute, store or use energy. The performance of these systems depends on the materials. Plastics, coatings, alloys and catalysts are some of the broad classes of materials used in current energy products. Advancements in these materials improve system efficiency and energy conversion processes, extend lifetime, and reduce 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 in batteries addresses low energy density, short cycle and calendar lifetimes, and high cost.