Introduction

The 2010-2011 portfolio marked the eighth year of GCEP activities with new, completed, and ongoing programs spanning nine topic areas. This technical report contains updates from over 20 currently funded research activities and nine completed programs. The summaries and results from ten exploratory programs are also provided.

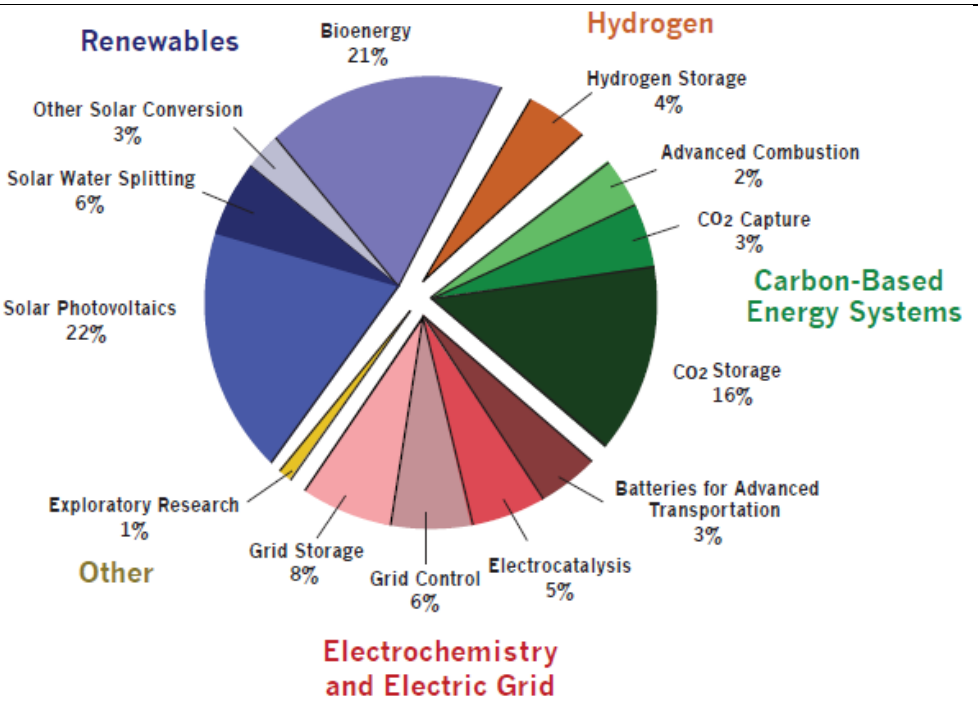
Progress reports from current GCEP funded research activities are described by topic area in Chapter 2 and final reports of projects that have reached completion during the past year are provided in Chapter 3. Investigators provide updates that include an abstract, introduction, results and progress, publications, and future directions.

Interest in exploratory research programs continues to grow as GCEP has seen a significant increase in the numbers of submitted proposals. As a result, the program has become more competitive. 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 provides the reports from the active and completed programs for 2010-2011, on topics that span the areas of Hydrogen Production, Distribution and Use, Renewable Energy-Solar, and Renewable Energy-Biomass, CO_2 Capture and Separation, CO_2 Storage, and Advanced Combustion. On average, around one-third of the programs which receive exploratory funds are successful at becoming fully funded, three year programs.

New programs in large-scale storage began in 2010, which provided depth to the Advanced Electric Infrastructure area and broadened the involvement of external institutions through multiple subcontracts. GCEP has now funded research across the following nine topic areas of its portfolio:

1. Hydrogen Production, Distribution and Storage
2. Renewable Energy - Solar
3. Renewable Energy - Biomass
4. Carbon Dioxide Capture and Separation
5. Carbon Dioxide Storage
6. Advanced Combustion
7. Advanced Materials and Catalysts
8. Advanced Transportation
9. Advanced Electric Infrastructure

The distribution of approved funds across the research portfolio is shown in Fig. 1. There is strong support for research in renewable energy sources as well as carbon-based energy systems and the electric grid. The funding distribution for 2010-11 only has minor percentage differences in a few categories compared with the previous year. The allocation of funds is expected to expand and change over time as major projects are completed and targeted funds address specific topic areas.



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 materials for high-performance photovoltaics to improve efficiency, reduce cost, and increase 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 a potential alternative to transportation fuels. Biomass research, like other renewable energy technologies, still needs to address issues of cost, conversion efficiency, energy density, and sustainability.

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.

To allow integration of renewable sources of electricity onto the electric grid and to achieve displacement of base load electricity supplied from fossil fuel sources, research aimed at understanding the grid operation and needs for storage is essential. The GCEP portfolio now includes studies on grid controls and large-scale storage, which will begin to address this issue.