Introduction

This report discusses the scope and adequacy of the GCEP portfolio of research activities. It includes reports from each of the three current GCEP Research Theme Leaders. Each report contains:

• a brief review of the general status and anticipated directions of research in their technical area;

• a discussion of the research needed in their area to achieve the GCEP goal of producing the scientific advances necessary to develop technology options that may enable significant reductions of greenhouse gas emissions from energy systems;

• a summary of the activities conducted at GCEP in their technical area, the major results from these projects during the past year, and the expected future directions of these projects through to their termination;

• a discussion of how current GCEP research fits in or is complementary to the research needed in their area to achieve GCEP goals; and

• recommendations of both topic areas in which GCEP should be seeking research projects, and external research groups that GCEP should be evaluating.

A summary of the principal recommendations for possible new topic areas is given below:

Solar
• Routes to Stable, Low Energy Threshold Organic Solar Cells
  ➢ Research to understand the causes of instability in light-sensitive organic materials and development of alternative approaches to improving organic cell stability.

• Alternatives to multi-junction cell approach, e.g.: hot-carrier cells
  ➢ Investigation of approaches, such as hot carrier cells, that have very high performance potential using a collaboration of several research teams.

Biofuels
• Discover New or Improved Enzymes for Decomposing Biomass into Sugars
  ➢ Identification of new enzymes that break down lignin or cellulose using the large amount of newly available microbial DNA sequence information, or discovery of new enzymes that can hydrolyze other polysaccharides.

• Create New Fuels
Engineering of major changes in the genes of microorganisms to develop new microbes that could produce alternative fuels to ethanol, such as longer chain alkanes, at high efficiency.

- **Create Novel Lignin**
  - Development of new types of lignin that are amenable to hydrolysis by enzymes or novel synthetic catalysts and that would then limit the need to use energetically expensive and chemically harsh treatments to preprocess biomass.

**Carbon Mitigation**

- **Coal to Liquids**
  - New low-cost approaches to generating liquid fuels without release of carbon beyond that in the product liquid.

- **Biomass to Liquids**
  - Energy-efficient approaches to generating fuels other than cellulosic ethanol, such as Fischer-Tropsch liquids, polyoxygenates, or other liquid carriers, from biomass.

- **Alternative End States for Carbon from Coal**
  - Innovative technologies for energy systems using coal as the energy resource and sequestering carbon in a form other than CO$_2$ through, for example, in-process mineralization.

- **Efficient Cost-effective Electricity from Coal**
  - Innovative concepts for modifying the boiler/steam cycle in cost-effective ways to improve efficiency so that there would be economic incentives to install more efficient pulverized coal plants.

- **Advanced Processes for Large Industrial Sources of CO$_2$**
  - New processes that include intrinsic CO$_2$ management that could be used in major industries such as mining, cement, and iron/steel.

The scope of this report is limited to the areas of expertise of the current set of three Research Theme Leaders. The GCEP portfolio also includes technical areas in which GCEP already has active research projects underway that are not covered in this report. These areas are hydrogen, carbon storage, and advanced materials and catalysts. This report does also not address the areas of advanced transportation systems, advanced nuclear, electric power, energy distribution systems and enabling infrastructures, and geoengineering which do not yet have research projects in place. GCEP intends to add more Research Theme Leaders who would be able to address the other areas of the GCEP technical portfolio in this report once an Executive Director has been appointed. The current set of GCEP Research Theme Leaders recommended adding a Research Theme Leader in the area of Advanced Materials for Electrochemistry and Energy Storage to improve coverage of the GCEP technical portfolio.