Overview of
The Global Climate and Energy Project

Lynn Orr, GCEP Director
The Need for Technology

• Concentrations of CO\textsubscript{2} will rise above current values (380 ppm), even under the most optimistic scenarios.

• Stabilization will require that emissions peak and then decline. Peak timing depends on the stabilized concentration.

• Improvements in efficiency, introduction of renewables, nuclear power, … all help.

• New technology will be needed for the really deep reductions.

Source: IPCC 2007
The Global Climate and Energy Project

**Goals**
- Fundamental, precommercial research
- Novel technology options for energy conversion and utilization
- Impact in the 10-50 year timeframe

**Strategy**
- Step-out research: revisit the fundamentals and explore new approaches
- High risk / high reward

**Budget**
- $225M commitment

**Participants**
- Industrial sponsors
- Academic institutions - Stanford and an increasing number of other universities worldwide
Current Portfolio

- $72.1M committed
- 47 3-year projects
- 69 investigators
- 20 institutions
- 225 students

Funding Distribution

Participating Institutions
Exergy Flow of Planet Earth (TW)

Current Global Exergy Usage Rate ~ 15 TW (0.5 ZJ per year)

Exergy Flow of Planet Earth (TW): Direct Solar Resource

Research Examples
- Solar Area

**Solar electricity**
- Organic photovoltaics
- Silicon-based quantum structures
- High efficiency thin-film concepts
- Efficient photon collection

**Solar hydrogen**
- Photoelectrochemical water splitting
Exergy Flow of Planet Earth (TW):

Bio Resources


\[ (1\, \text{ZJ} = 10^{21}\, \text{J}) \]
Research Examples
- Bio Area

**Biomass**
- Genetic engineering of cellulose accumulation

**Bio-hydrogen**
- Hydrogenase enzyme
- Genetic evolution of biological systems (bacteria) to produce hydrogen

**Bio-electricity**
- Direct current extraction from the chloroplast of photosynthetic cells
Exergy Flow of Planet Earth (TW):
Fossil Hydrocarbon Resource


(1 ZJ = 10^{21} J)
Research Examples
- Carbon Mitigation Areas

**Advanced combustion**
- High-efficiency IC engines with theoretical efficiency limits of ~ 60%

**CO₂ separation**
- Novel nanostructured polymeric and inorganic membrane materials

**CO₂ sequestration**
- Study of the long-term stability and seal integrity of geologic structures (aquifers, oil and gas reservoirs)

- Cardo polyimide hollow fiber membrane

- Membrane reactors combining NG reforming and C capture

- Hydrotalcite membrane

- Integrated coal thermal conversion process in supercritical conditions using aquifer brine as a solvent and storage medium
GCEP Goals

- A research-base for technologies that would permit substantial reductions in greenhouse gas emissions due to energy use
- A highly trained pool of researchers to address the remaining technological issues
- A better-informed technical community concerning the technical barriers and potential solutions concerning greenhouse gas emissions from energy production and utilization
- A model for industry-sponsored research to address global technological issues
Advanced Electricity Infrastructure

- Opportunity to reduce CO$_2$ emissions
  - 7-10% of electricity generated is lost through transmission and distribution
- Understand the needs and impacts to integrate other GCEP portfolio areas with electricity infrastructure,
  - e.g. advanced combustion, renewables, transportation
- Enable the integration of new technologies and infrastructure paradigms at a national and global scale.
The Workshop

• Define the technical issues
• Identify research opportunities that are relevant to GCEP and address the technical issues
• Develop a portfolio of fundamental research in advanced electricity infrastructure
Questions for the Workshop

• What are the research priorities in your area of investigation and why?
• What barriers exist to successful research and what breakthroughs are needed?
• What are the opportunities for fundamental, academic research to develop pathways for technologies to overcome the barriers?
• Where do you feel that a contribution by a project such as GCEP could have the most impact?
More Questions

• Where are major inefficiencies and losses in the power system (not including generation or end-use)?

• Assuming 50% penetration of renewables into the grid and no storage, what does the power system need to look like, and how would it operate?

• In a carbon-constrained world, how could the power system change to accommodate the demand for transportation?

• What would be game-changing scenarios for the electric grid?
Workshop Agenda
Day 1

**Welcome and Introduction**
8:30   GCEP Introduction and Workshop Purpose          Lynn Orr
9:00   Power System Introduction and Overview          Thomas Overbye
9:40   California Grid Operations                      Jim Detmers
10:20  Break                                           
11:35  Industry Perspectives                          Juan de Bedout

**Advanced Transmission**
11:15  High-Temperature Superconducting Transmission   Michael Gouge
11:55  Lunch                                           
12:55  Power Quality Requirements for Reliability     Surya Santoso
1:35   Quantum Wires for Grid Applications             Matteo Pasquali

**Power Systems, Control and Analysis**
2:15   Distributed Solutions for Grid Control          Deepak Divan
2:55   Break                                           
3:10   Integration Technologies for Power Flow Controllers  Khai Ngo
3:50   Enhanced State Estimation                        Ali Abur
4:30   Computational Issues for Intelligent Grids      Bruce Wollenberg

5:10   Reception
Workshop Agenda
Day 2

Opening
8:30  Visions for the Utility of the Future  
      David Mohler

Distributed Generation
9:10  Perspectives on Vehicles to Grid  
      Michael Kintner-Meyer
9:50  Impacts and Needs for Renewables in DG Integration  
      Giri Venkataramanan
10:30 Break
10:50 Distributed Generation Expansion  
      Kevin Tomsovic
10:50 Voltage Control with Distributed Generators  
      Fangxing (Fran) Li
12:05 Lunch

Storage for Distributed Resources
1:05  Energy Storage: A Distributed Resource  
      Imre Gyuk
1:45  Battery Materials for Grid Applications  
      Glenn Amatucci
2:25  Kinetic Energy Storage and Power Generation  
      Robert Hebner
3:05 Closing Remarks

3:10  Speaker Roundtable Discussion
Thank You!

**GCEP Staff and Emilie Hung**
- for the technical organization of the workshop

**Nancy Sandoval**
- for organizing everything else

**Our Sponsors**
- for making this project possible

**Our Speakers**
- for sharing your time, expertise, and opinions with us

**The Energy Community**
- for taking time to participate in our discussions