GCEP

Stanford University

Global Climate & Energy Project

April 27, 2004

Introduction to the GCEP Carbon Capture and Separation Workshop

Lynn Orr

Global Climate & Energy Project

- A research project to develop new technology options for a low GHG future.
- Industrially sponsored: ExxonMobil, General Electric, Toyota, Schlumberger
- Ten-year project seeking options for the 10-50 year time frame.
- Defining what is possible is a key element of developing ideas for new options.
- The objective of this meeting is to consider what is possible in the area of CO_2 separations.

The Grand Challenge

Needs

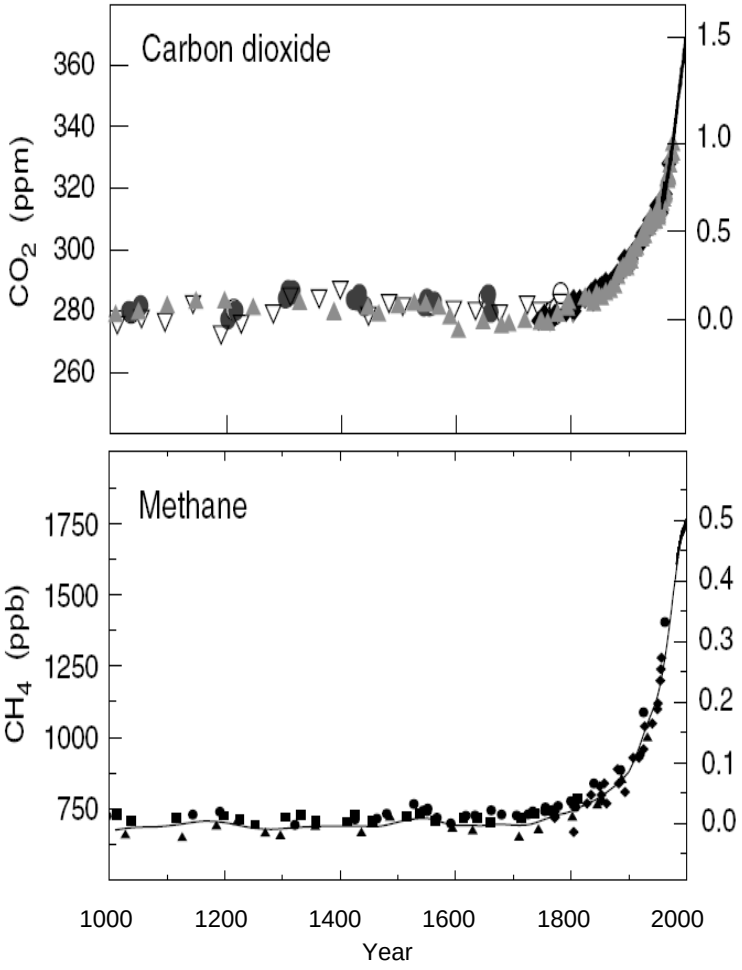
- Growth in world population to 9 billion from 6 billion, of which 2 billion people currently have no access to modern energy systems
- Improved standard of living in growing economies of developing world
- Increased demands for energy, food, land, and materials.

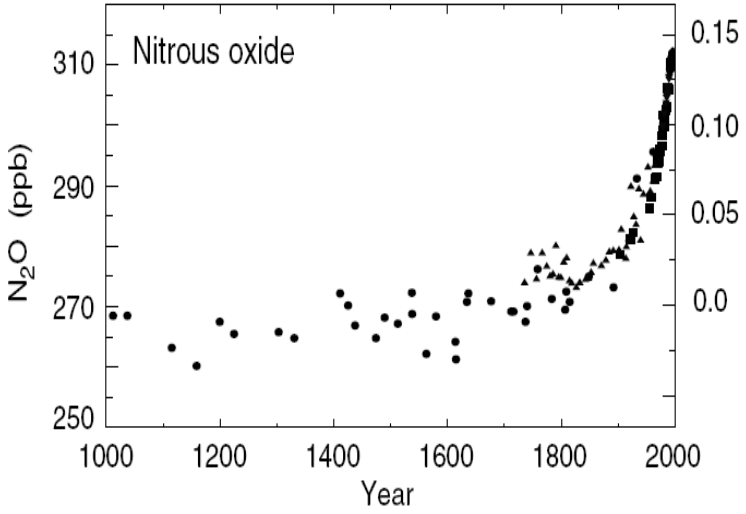
Protection, Restoration, and Improvement of the Planetary Biogeochemical Systems

Component Challenges

- Water supply
- Agricultural systems (strongly linked to water supply)
- **Energy (with possible limits on CO_2 emission)**

Global Geochemical History

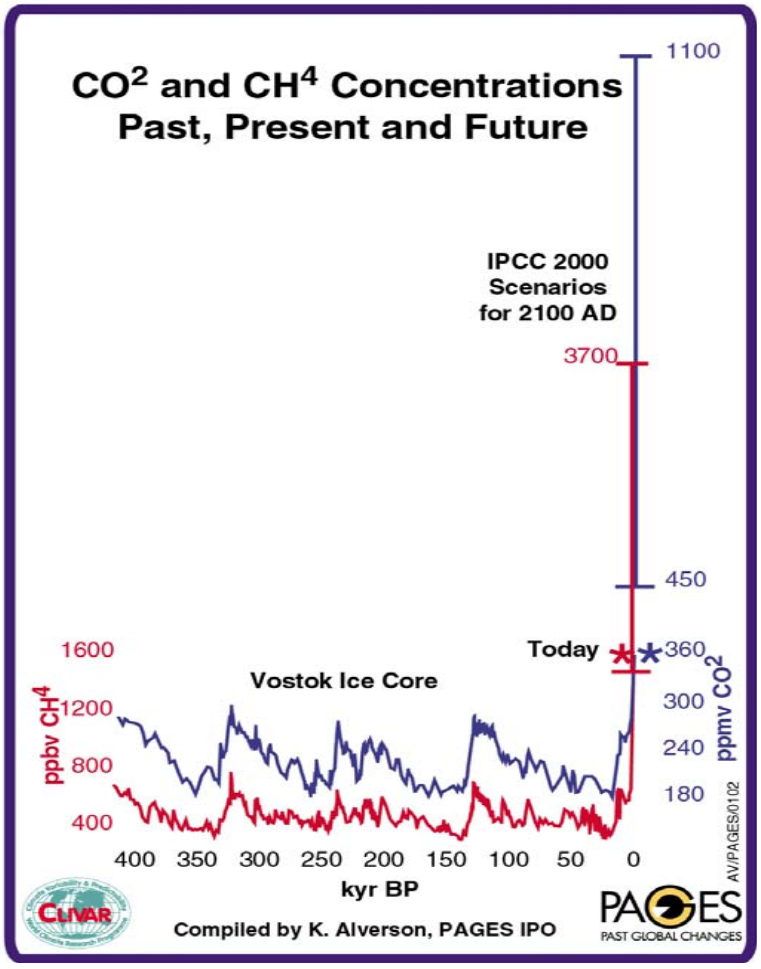


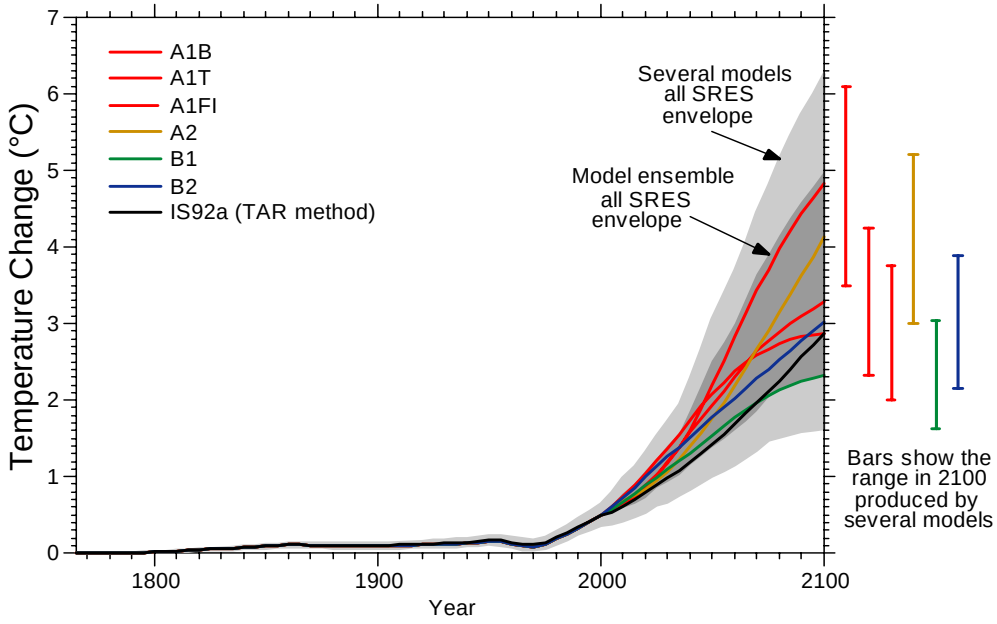


- Concentrations of GHGs have risen significantly over the preindustrial levels.
- Surface ocean pH has also declined by 0.1 as additional CO_2 dissolved.

Source: IPCC Third Assessment Report, 2001

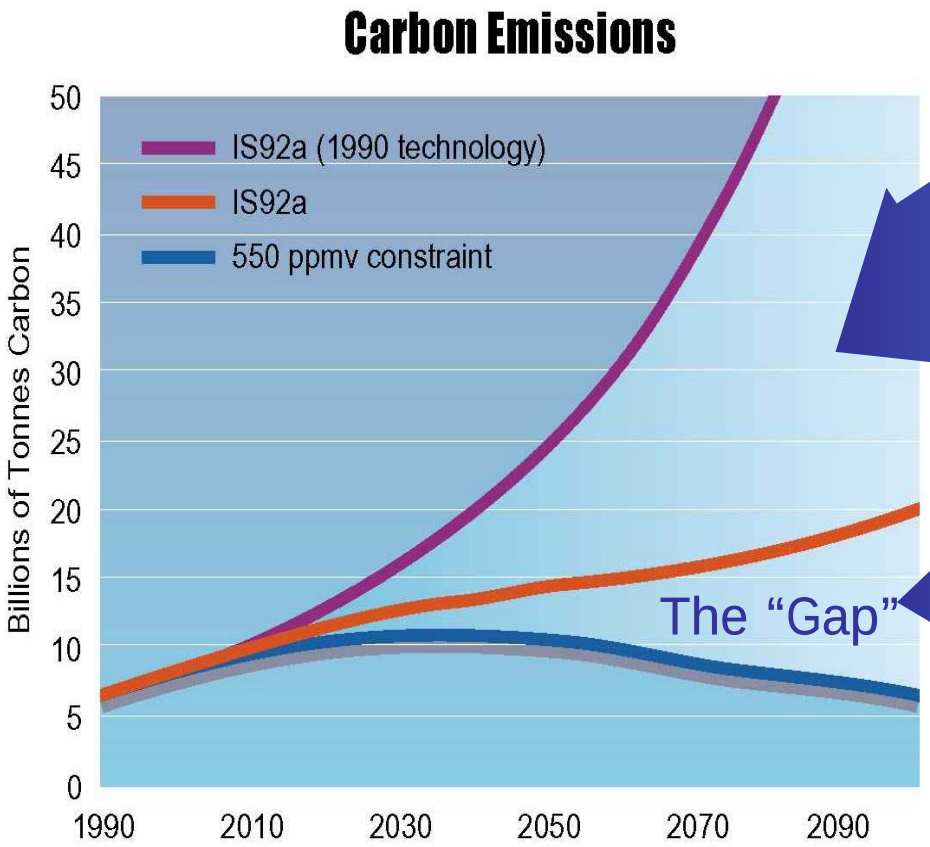
Future Projections





IPCC 3rd Assessment Report (2001) –
Projected Global Temperature Change

The Need for Technology



Assumed Advances In:

- Fossil Fuels
- Energy intensity
- Nuclear
- Renewables

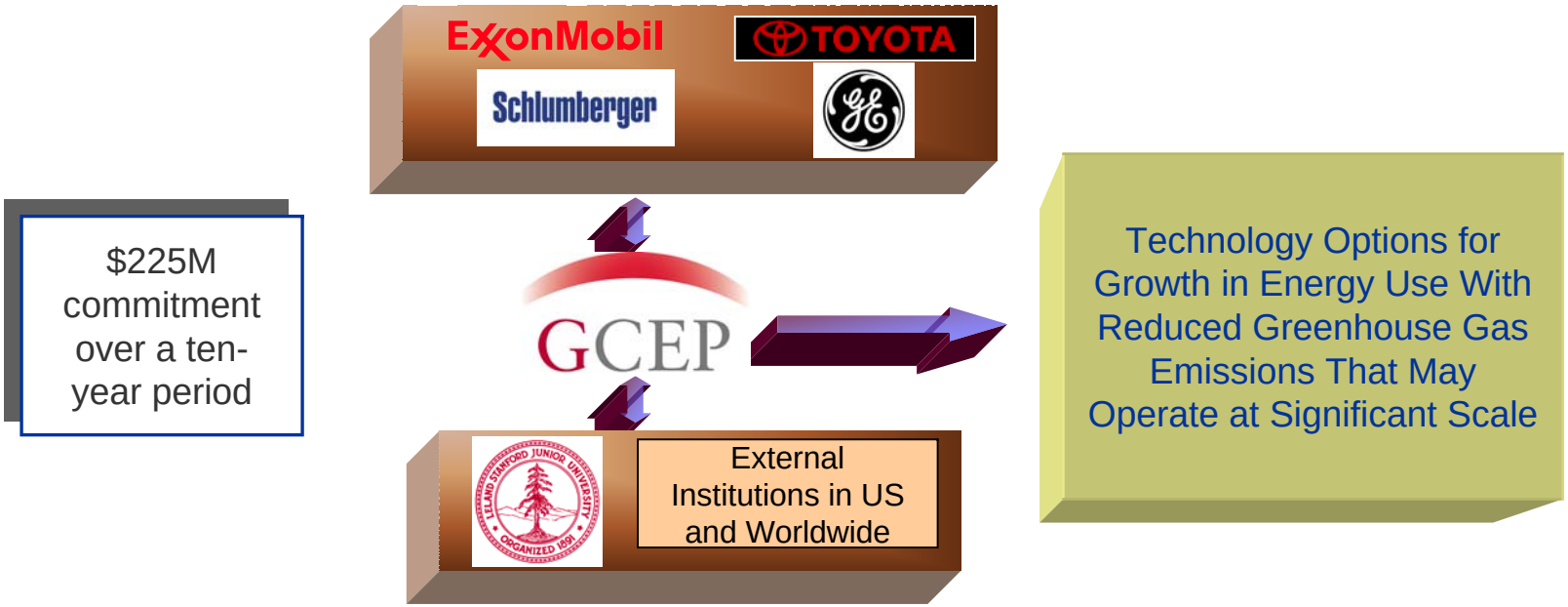
Gap Technologies:

- Carbon capture & disposal
  - Adv. fossil
- H_2 and Adv. Transportation
- Biotechnologies
  - Soils, Bioenergy, Adv. Biological Energy

Source: J. Edmonds, PNNL

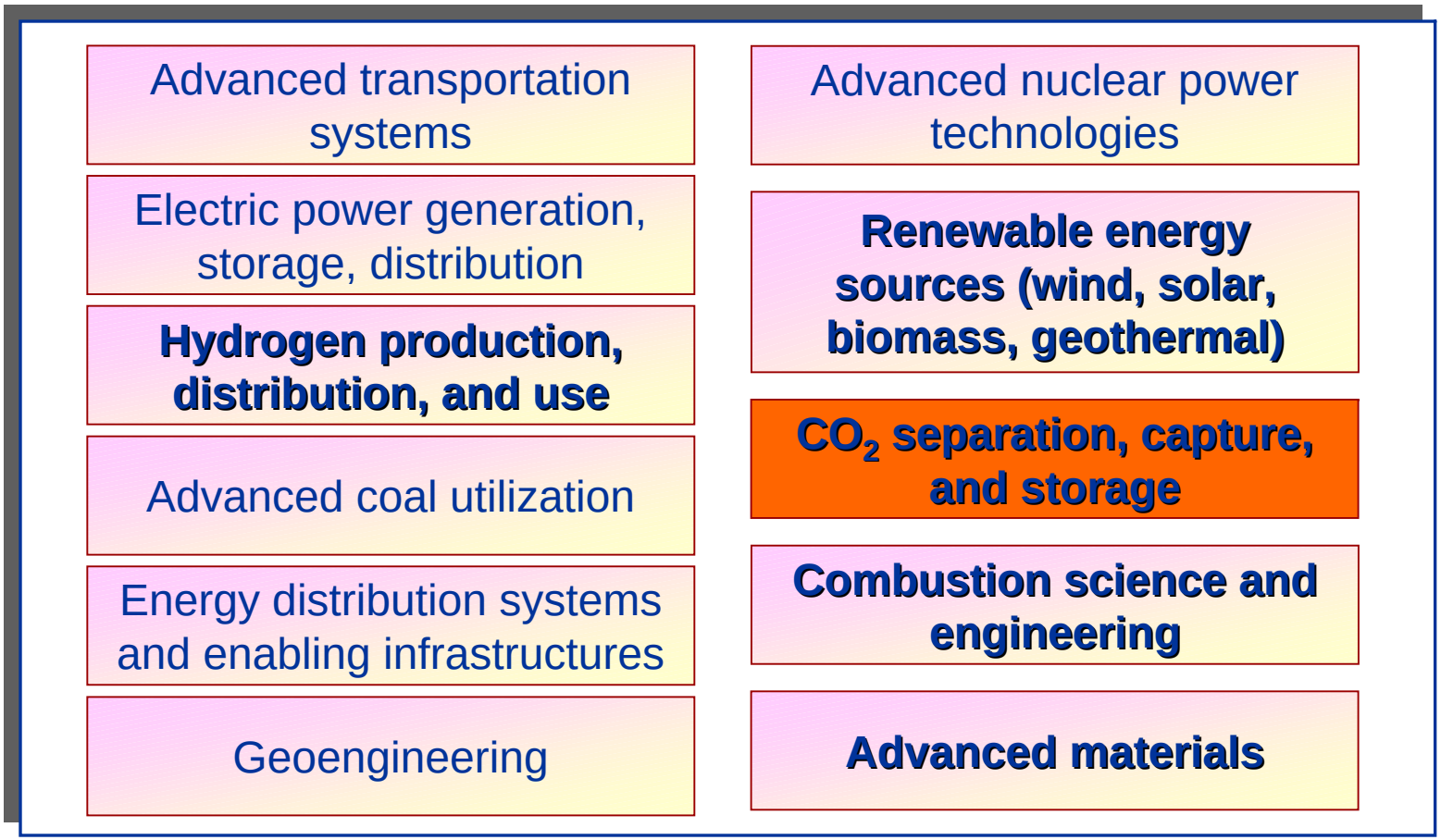
The GCEP R&D Program to Generate Technology Options

- The Global Climate and Energy Project (GCEP) was established to conduct pre-commercial research necessary to develop the technology options needed to address the “gap”
- It represents a long-term commitment to developing step-out technologies that may have a significant impact on a global scale



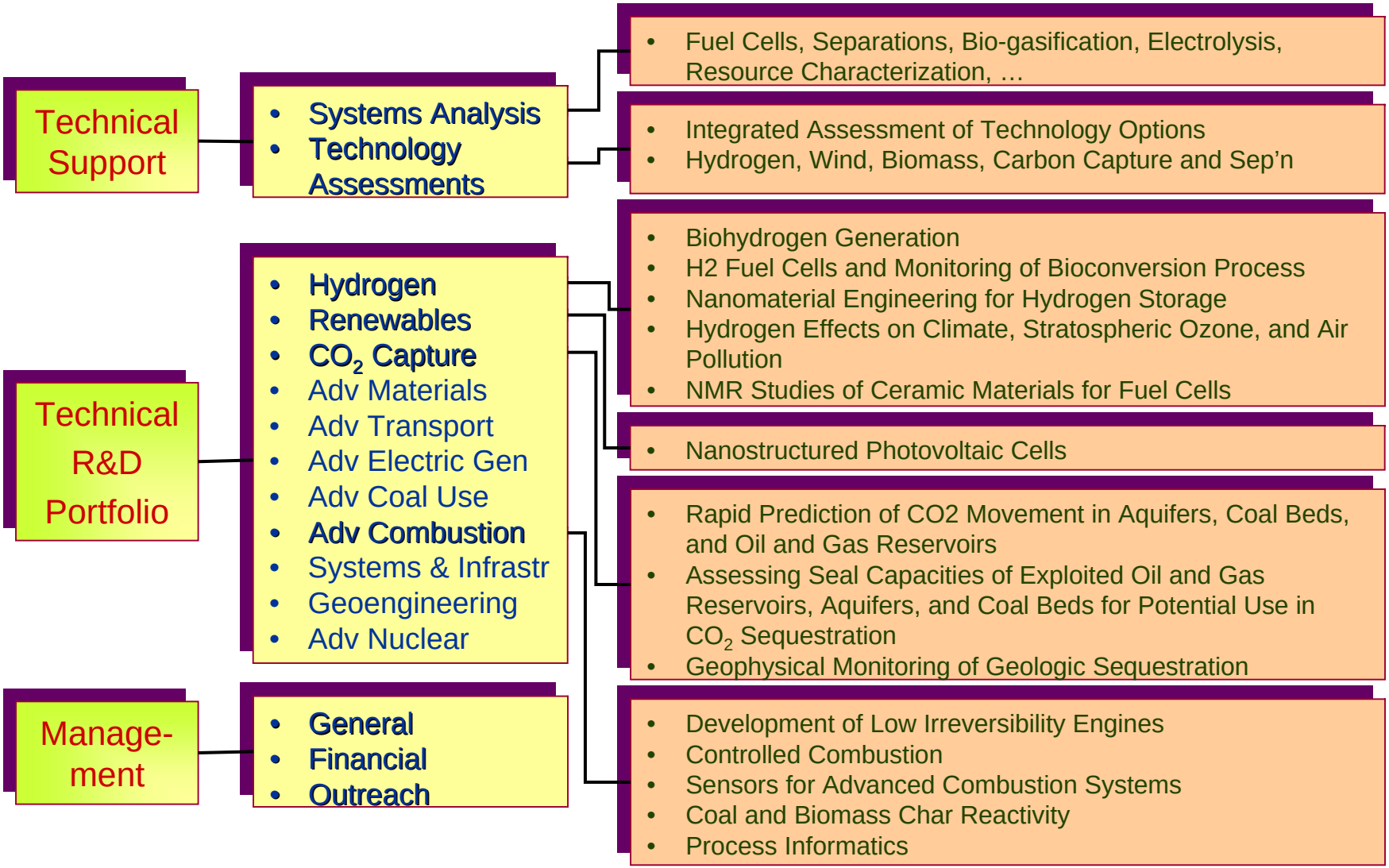
Portfolio Areas

- GCEP mandate includes 11 technical areas



Technical Areas with Projects currently underway

Current GCEP Projects



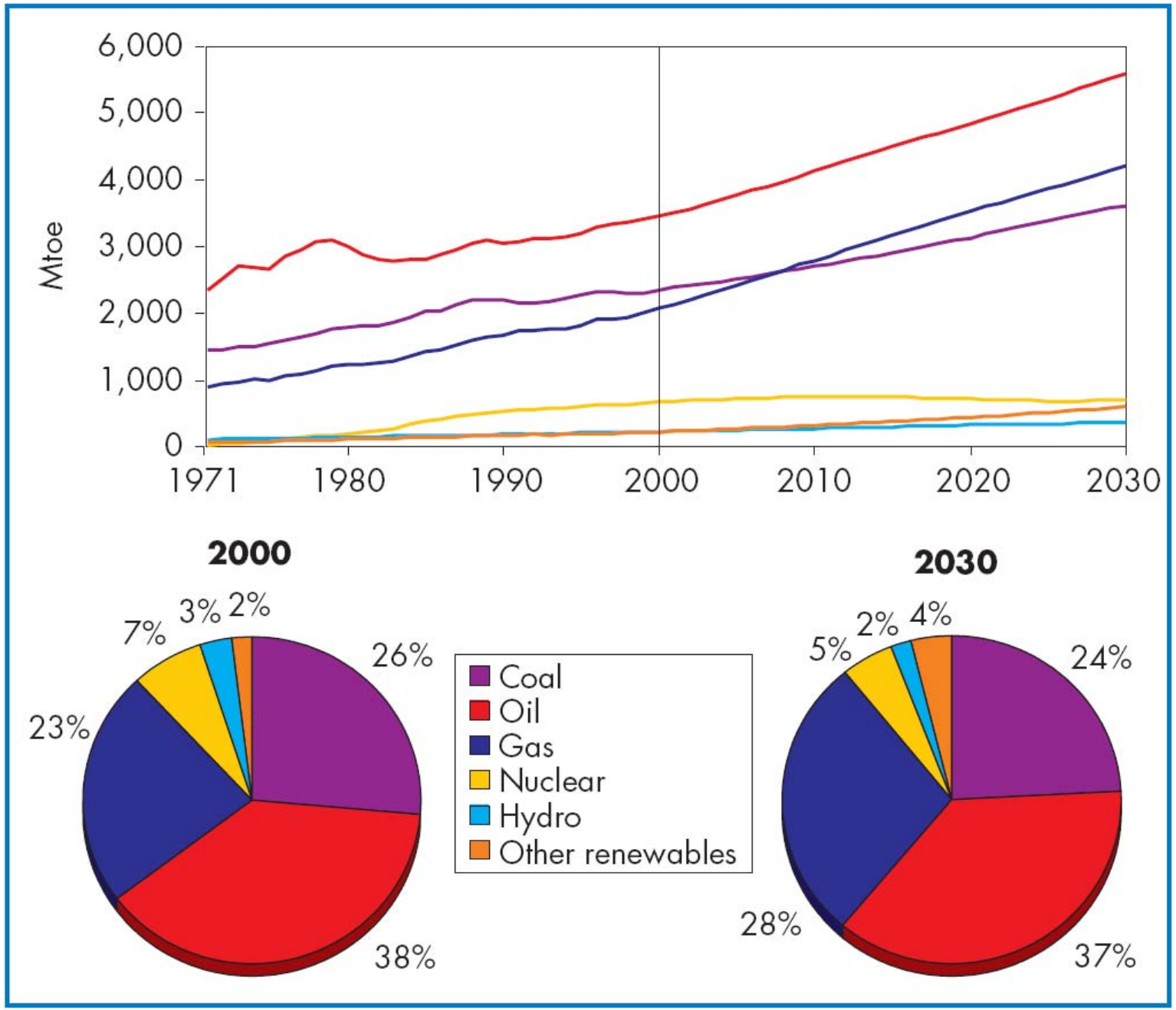
Fossil Fuels

"Fossil fuels supply 85 percent of U.S. energy and 75 percent of energy globally. They will continue to be essential to the energy economies of the United States and the world well into the twenty-first century"

"… prudence requires having in place an adequate energy R&D effort designed to expand the array of technological options relevant to the risks of greenhouse gas-induced climate change."

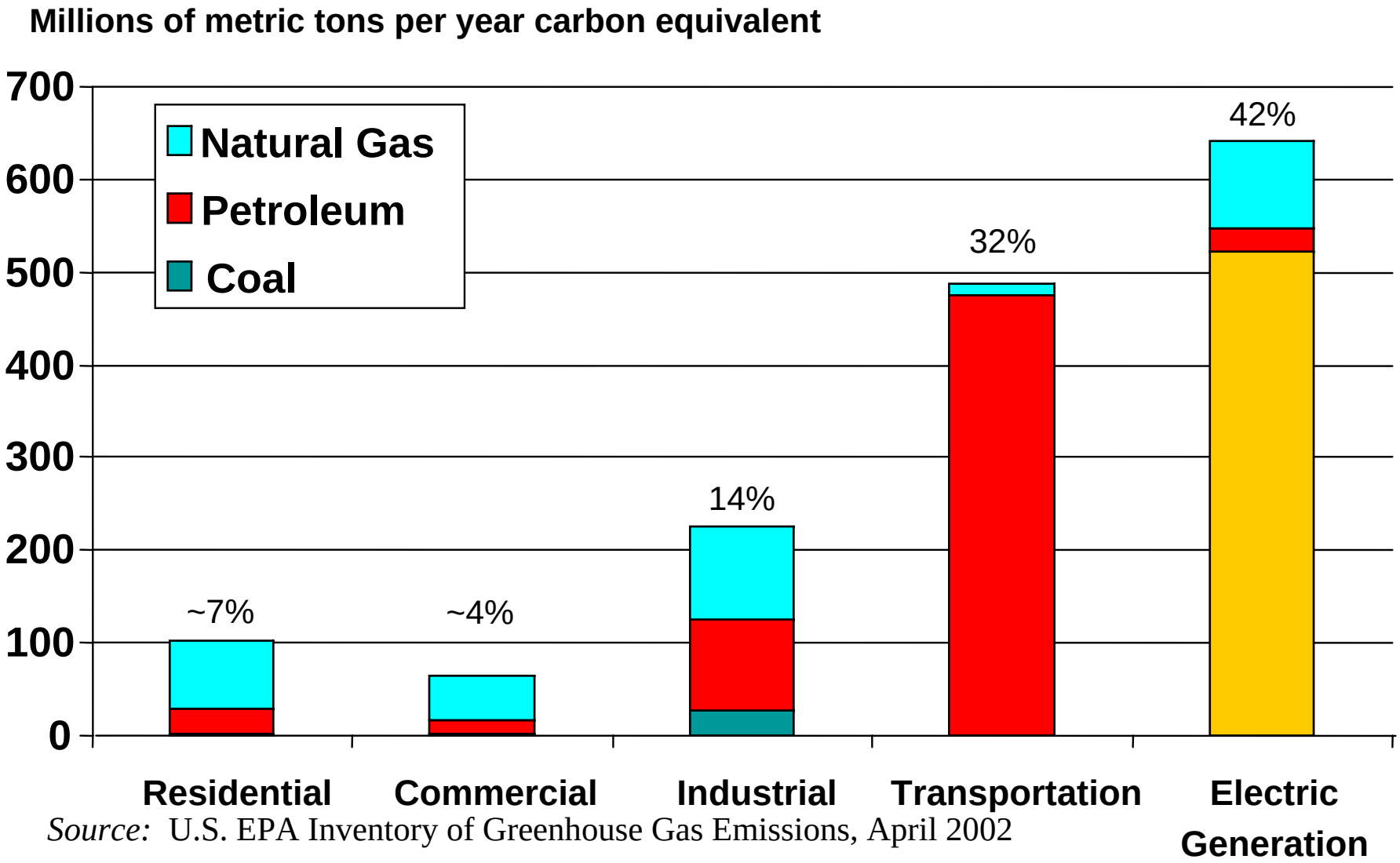
– Report to the President on Federal Energy and Development for the Challenges of the Twenty-First Century, President's Council of Advisors on Science and Technology (PCAST)

Figure 2.1: **World Primary Energy Demand**



Source: OECD/ IEA, Paris, *World Energy Outlook 2002*, Second Edition, November (2002)

United States CO_2 Emissions in 2000



Source: U.S. EPA Inventory of Greenhouse Gas Emissions, April 2002

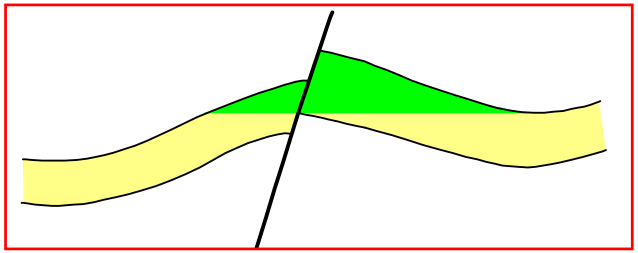
Carbon Capture and Storage

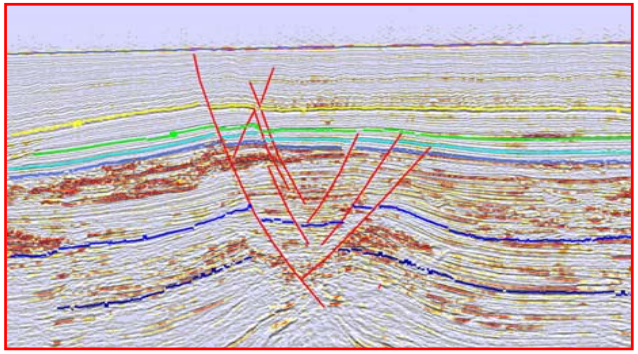
- Whatever transitions take place over this century, fossil fuels are likely to continue to be used for an extended period.
- If so, then limiting CO_2 release to the atmosphere will require some sort of CO_2 capture and subsequent sequestration (a topic for another day!).
- The challenge is a huge one: 1 billion tonnes/yr of CO_2 is 25 million barrels/day at reservoir conditions.
- Separation technologies are critical to the success of any substantial effort on CO_2 sequestration.
- This workshop will explore research opportunities for advanced technologies for CO_2 capture.

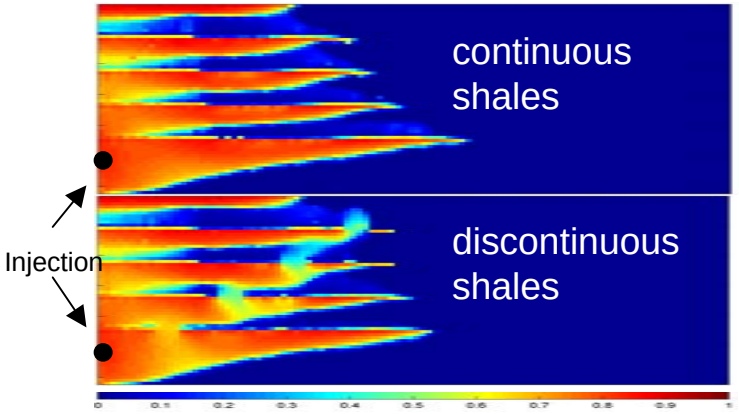
Geologic Storage of CO_2

Mark Zoback, Jerry Harris, Tony Kovscek, Lynn Orr

- Create a suite of tools for design and implementation of geologic sequestration projects:
  - Site selection and evaluation: effective methods to assess the integrity of geologic seals that limit CO_2 migration.
  - Fluid migration: very efficient methods for predicting the flow paths and long-term fate of injected CO_2.
  - Monitoring: appropriate tools for monitoring the state of injection projects at each stage.







Capture Options

- Solvent methods
- Solid adsorption
- Membranes
- Cryogenic separations
- Clathrates
- ?

Questions to Ponder Today

- Are there opportunities for technology research in CO_2 separations that might lead to game-changing options for CO_2 capture?
- What elements should be present in a portfolio of research on CO_2 capture?
- Where are the best opportunities for reductions in the cost (energy and economic) of CO_2 capture?

Thank You!

- to our sponsors—for making this project possible
- to our speakers—for sharing your time, expertise, and opinions with us
- to our faculty—for considering how you can contribute to this problem of global importance in your research groups
- to the energy community—for taking time to participate in our discussions
- to our students—for providing the ideas, energy, and implementation needed to meet this challenge.

More Thanks

- Session Chairs (Jerry Harris, Mark Zoback, Tony Kovscek, Howard Herzog)
- Harry Johnson, SFA Pacific
- Kersti Miller and Nancy Sandoval
- Other GCEP staff and students

Agenda

8:30–9:00	**Welcome and Introduction**
8:30	*GCEP Introduction and Workshop Objective,* Lynn Orr, *GCEP*
9:00–10:30	**Session 1: *Overview, Chair: Jerry Harris***
9:00	*NETL Carbon Sequestration Program—US Perspective on CO_2 Capture and Separation,* Jared Ciferno, *U.S. DOE - NETL*
9:30	CO_2 Separation—State of the Art and Future Prospects, Rodney Allam, *Air Products and Chemicals, Inc.*
10:00	Key Findings of the CO_2 Capture Project (CCP), Cliff Lowe, *ChevronTexaco Energy Technology Company*
10:30–10:45	**BREAK**
10:45–12:15	**Session 2: *Recent Technology Developments, Chair: Anthony Kovcek***
10:45	CO_2 Separation with Molecular Membrane Systems, Shingo Kazama, *RITE, Japan*
11:15	Solvent Development for Aqueous Absorption/Stripping of Carbon Dioxide, Tim Cullinane, *The University of Texas at Austin*
11:45	Panel Discussion
12:15–1:15	**LUNCH**
1:15–2:45	**Session 3: *Large-Scale Applications, Chair: Mark Zoback***
1:15	Opportunities for Large-Scale Carbon Capture in Co-Production of Liquid Fuels and Power, Robert Williams, *Princeton University*
1:45	CO_2 Removal From Natural Gas, Rusty Kelley, *ExxonMobil Upstream Research Company*
2:15	*MHI's Flue Gas CO_2 Recovery Technology,* Masaki Iijima, *Mitsbubishi Heavy Industries, Ltd.*
2:45–3:00	**BREAK**
3:00–5:30	**Session 4: *Novel Technological Approaches, Chair: Howard Herzog, MIT***
3:00	Carbon Dioxide Separation from Multi-Component Gas Streams Using Clathrate-Hydrates, Robert Currier, *Los Alamos National Laboratory*
3:30	Development of Regenerable, Sodium-Based Sorbents for CO_2 Capture, Raghubir Gupta, *Research Triangle Institute*
4:00	Novel Vortex Membranes for CO_2 Capture and Separation, Joseph Perkowski, *INEEL*
4:30	Panel Discussion—Research Opportunities, Howard Herzog, *MIT*
5:00	Concluding Remarks / Adjourn, Lynn Orr, *GCEP*