



Stanford University  
**Global Climate & Energy Project**

Carbon Management in the Manufacturing Industries Workshop  
April 15-16, 2007

**Welcome**  
**Introduction to GCEP and the Workshop**

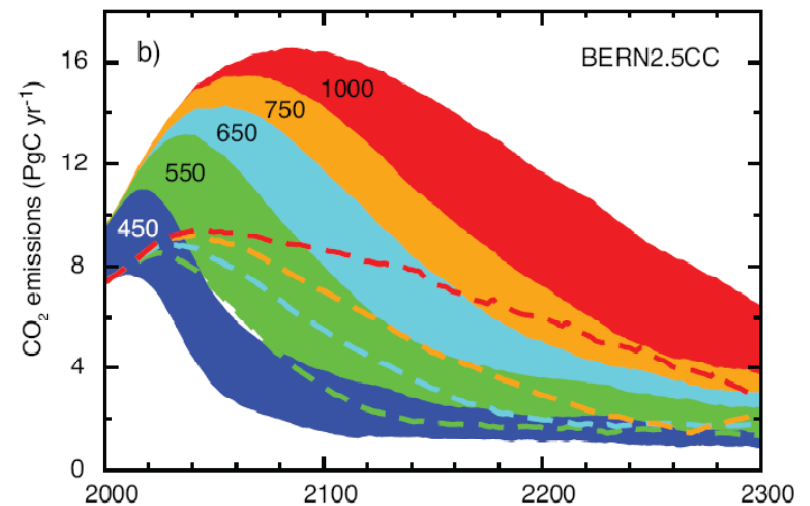
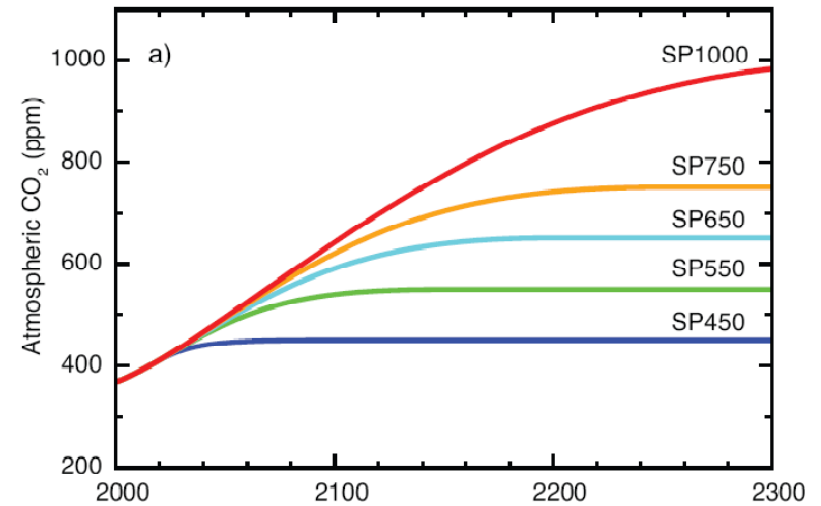
**A.J. Simon, Energy Systems Analyst**



# The Need for Technology



- Concentrations of CO<sub>2</sub> 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



# GCEP Overview



## Mission

- Research on low-GHG emission energy conversions
- Focus on fundamental and pre-commercial research
- Applications in the 10-50 years timeframe

## Strategy

- Research projects with potential for significant impact on GHG emissions
- Look for potential breakthroughs for new conversion options
- High risk / high reward
- Work at Stanford and at other institutions around the world

## Schedule and Budget

- 10 years (2003 – 2013+)
- \$225 M





# GCEP Funded Institutions



## USA

Stanford University  
Boise State University  
Brigham Young University  
California Institute of Technology  
Carnegie Institution of Washington  
Harvard University  
Purdue University  
SRI International  
UC Santa Cruz  
University of Montana  
University of Wisconsin

## Europe

ECN  
ETH Zürich  
IRDEP/CNRS  
TU Delft  
University of Dundee  
Ghent University  
Universite de Picardie Jules Verne  
Universidad Politécnica de Madrid  
Uppsala University  
Utrecht University/FOM

## Japan

RITE

## Australia

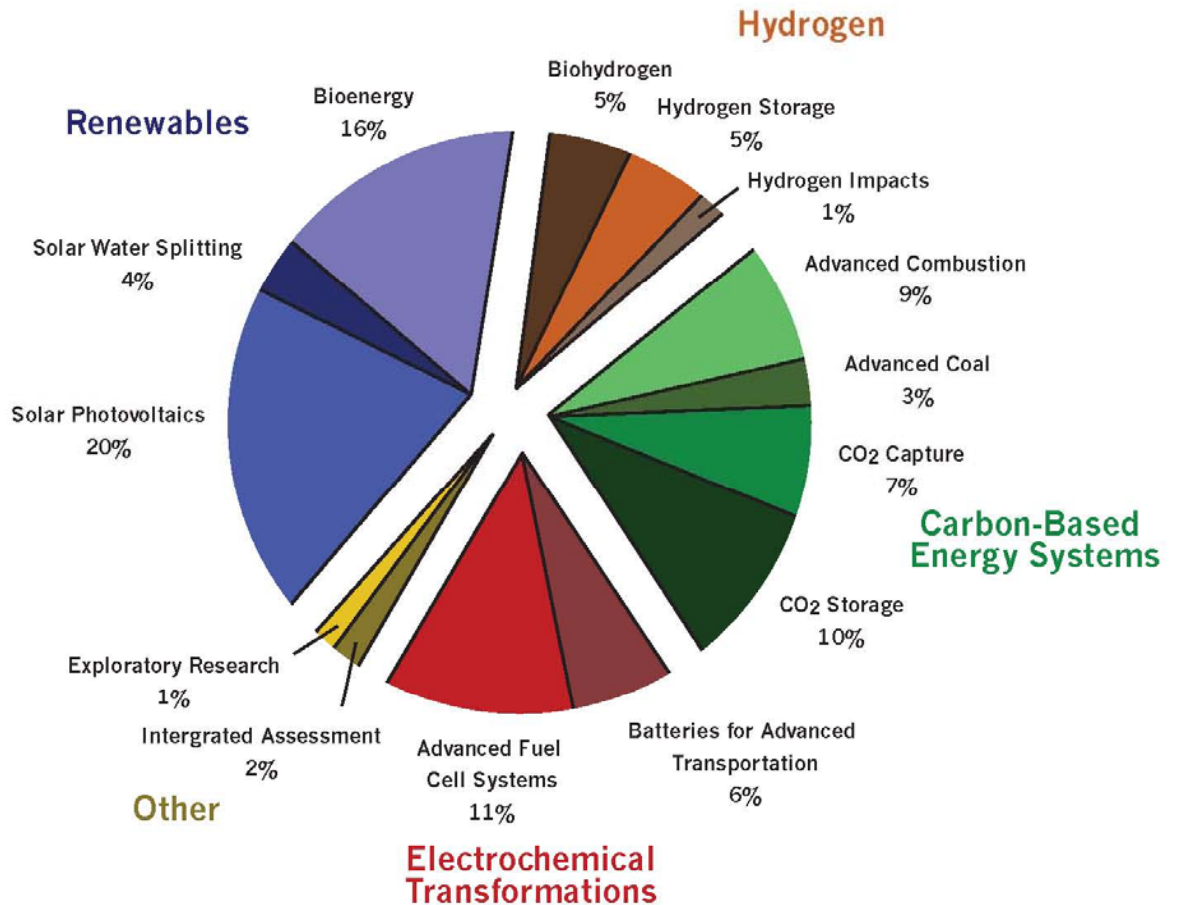
UNSW  
University of Sydney



# GCEP Portfolio



- \$111 million allocated
- 44 full-term projects
- 11 exploratory projects
- 24 institutions
- 17 Stanford departments
- over 300 graduate students and post-docs
- 6 patent applications





# GCEP Goals

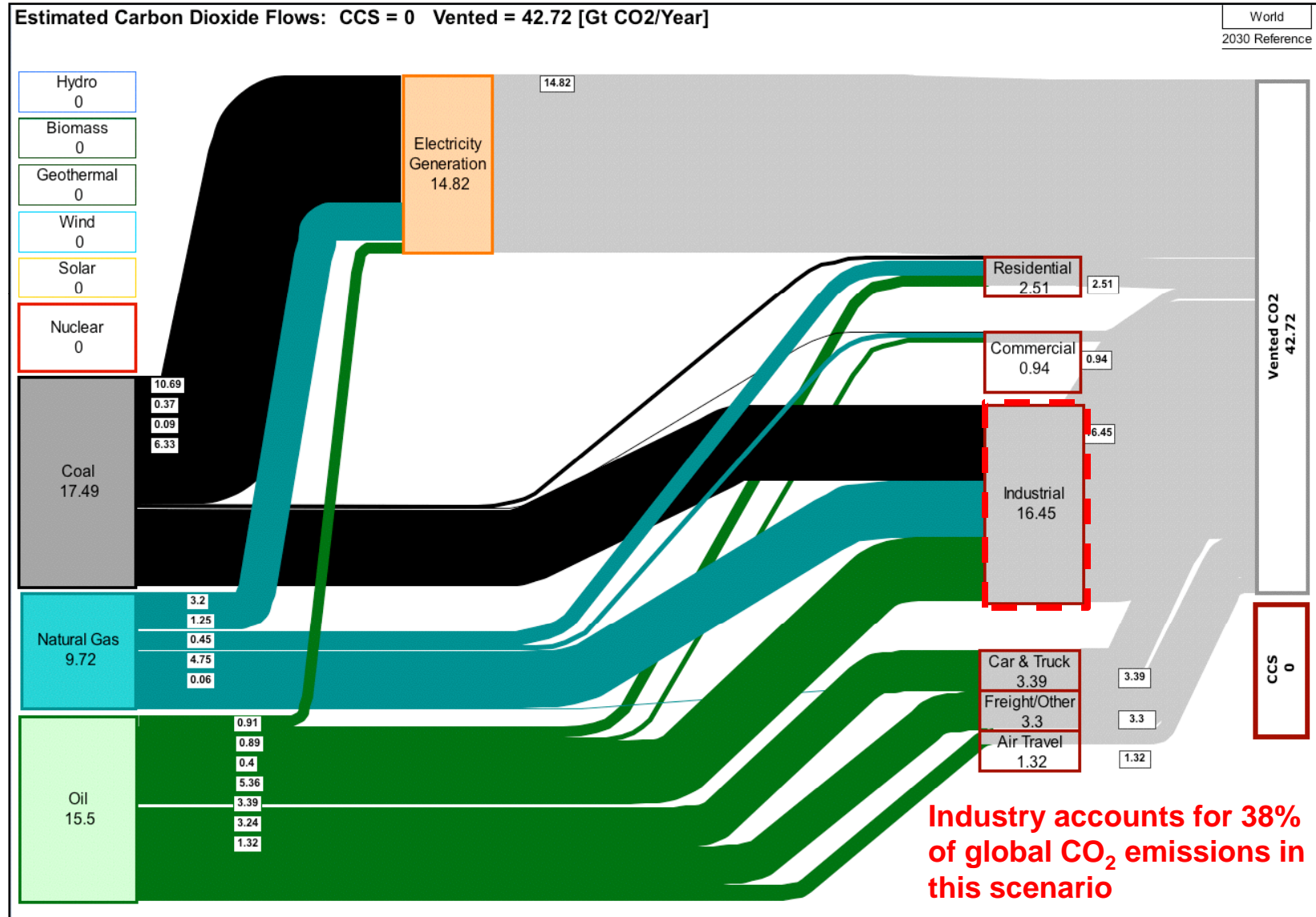


- A research-base for technologies that would permit substantial reductions in greenhouse gas emissions due to energy use
- A highly trained pool of researchers to address the remaining technological issues
- A better-informed technical community concerning the technical barriers and potential solutions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



# LLNL Carbon Flowchart

## 2030 EIA International Energy Outlook





# Cement



- $\text{CaCO}_3 \rightarrow \text{CaO} + \text{CO}_2$
- Endothermic reaction
- ~1/2 carbon comes from  $\text{CaCO}_3$ , other half comes from fuel
- Highest (sintering) temperatures employ radiative heat transfer



Image: FLSmidth



# Refining



- CO<sub>2</sub> emissions are a fraction of total carbon throughput
- Separations require free energy
- Upgrading to higher H/C ratios:
  - adding H requires free energy
  - removing C results in carbon emissions or coke



Image: BP



# Steel



- Blast furnace coke is a chemical reductant
- Coke is also a structural element in the reactor stack
- Energy efficient 3-phase reaction
  - Solid feedstocks
  - Liquid metal product
  - Gaseous feed/waste



Image: U.S. Steel



# 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 industrial materials processing and manufacturing



## 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



- How would low- or zero-cost carbon sequestration change the game, and what barriers to capturing carbon would remain?
- If carbon-free energy carriers were cost competitive with current feedstocks, what technical and economic challenges would prevent the switch to those fuels?
- What are the opportunities for disparate industries to collaborate on carbon management?
- How can industry's specialized knowledge of process engineering and material handling address the grand challenge of reducing carbon emissions?



# Workshop Agenda

## Day 1



### Welcome and Introduction

8:15 GCEP Introduction and Workshop Purpose A.J. Simon

### Cement

8:30 European Cement Overview Volker Hoenig  
9:00 Novel Cement Materials Brent Constantz  
10:10 CO<sub>2</sub> and Kiln Dust Mitigation Greg Rao  
10:40 Oxyfuel Cement Kilns Frank Zeman  
11:10 Calcium Sorbent Cycling Carlos Abanades

### Refining, Petrochemicals and Process Integration

1:00 GHG Reduction at Chevron Susann Nordrum  
1:30 Efficient Separations in Refining Bruce Eldridge  
2:00 Challenges and Opportunities for Refining Theresa Hochhalter  
3:10 The US Chemical Chemical Industry Nesrin Ozalp  
3:40 Heat and Mass Integration Eva Lovelady

4:30 *Reception*



# Workshop Agenda

## Day 2



### **Iron and Steel**

8:30	ULCOS	Mark Atkinson
9:00	US Steel Industry, Advanced Technology	Joe Vehec
10:10	Hydrogen as a Reductant for Iron Ore	H.Y. Sohn
10:40	Sustainable Ironmaking	Wei-Kao Lu
11:10	Electrolytic Ironmaking	Don Sadoway

### **Other Industries, Energy Efficiency and Crosscutting Issues**

1:00	Exergy Efficiency of Manufacturing Processes	Tim Gutowski
1:30	CO <sub>2</sub> Mitigation from Foundries	Fred Cannon
2:00	Co-production of Syngas with Metals or Lime	Martin Halmann
3:10	The Built Environment	Marc Porat
3:40	Industrial CO <sub>2</sub> Mitigation Experience	Mike Grossner



Thank You!



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## GCEP Staff

- Girley, Nancy, Clare, Maxine

## GCEP Management

- for encouragement to look in a new area

## 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
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