Goal: The goal of the meeting is to understand progress to date, to exchange information about fuels, carbon storage and future scientific advances, and to produce a shared commitment to the objectives of Year-5 and beyond.
Carbon Mitigation Initiative
FOURTH ANNUAL MEETING

Princeton University
Wednesday, January 12, and Thursday, January 13, 2005

AGENDA — Wallace Room 300
Wednesday, January 12

8:30 – 9:00 am  Welcome and Safety Moment
                 Introductions and Meeting Expectations Pacala/Socolow/Hill
9:00 – 9:30 am  Background and Context: History of CMI, Goals of the Meeting (Pacala)
9:30 – 10:00 am Carbon Science Update (Sarmiento)
10:00 – 10:30 am Carbon Storage Update (Scherer)
10:30 – 10:45 am Break
10:45 – 11:45 am Carbon Capture and Integration Update (Socolow)
11:45 – 12:05 pm Update from BP
12:05 – 12:25 pm Update from Ford
12:30 – 1:30 pm  Lunch and talk by Steve Koonin (BP) CO₂ Stabilization: Observations and Questions
1:30 – 4:00 pm  Capture Workshop – The Future of Fuels: Roles for Low-Carbon Strategies
4:00 – 4:15 pm  Break
4:15 – 5:45 pm  Executive Session
6:00 – 6:30 pm  Reception at Prospect House
6:30 – 8:30 pm  Dinner at Prospect House

Thursday, January 13th

8:30 – 8:45 am  Welcome and Safety Moment
8:45 – 11:45 am Geological Storage Workshop
12:00 – 1:00 pm Lunch w/ Feedback from the Advisory Group
1:00 – 3:00 pm  Science Workshop - Advances to Expect in Carbon and Climate Science Over the Next Ten and Twenty Years
3:00 – 3:30 pm  Meeting Wrap-up and Adjourn. What did we learn?
                 Pacala/Socolow/BP/Ford
Outline

• Where we started: history of the CMI (this talk).
• Where we are now. Accomplishments in year 4 and a tentative plans for year 5 (next 3 talks).
LAUNCH OF THE AGREEMENT


October 2000. BP and Ford Motor Company jointly announce the formation of the Carbon Mitigation Initiative (CMI) at Princeton University to develop new approaches to carbon management.

“CMI will focus on resolving the fundamental scientific, environmental, and technological issues that ultimately will determine public acceptance of carbon management strategies. It will search for strategies that: 1) will have the desired effect on atmospheric carbon and climate; 2) will be safe and reliable with limited environmental impact; and 3) will involve neither prohibitive economic costs nor prohibitive disruption of patterns of energy consumption.”

Recognizing the complexity and durability of the issues, both BP and Ford Motor Company make a ten-year commitment, with BP funding of $15,100,000 and Ford Fund funding of $5,000,000.

December 2000. Kickoff meeting is held in Princeton.
CMI Mission Statement

The vision of the CMI is to lead the way to a compelling and sustainable solution of the carbon and climate change problem. By combining the unique and complementary strengths of the CMI parties — one premier academic institution and two influential global companies — CMI participants seek to attain a novel synergy across fundamental science, technology development, and business principles that accelerates the pace from discovery, through proof of concept, to scalable application.
CMI Goals

CMI will focus on resolving the fundamental scientific, environmental, and technological issues that ultimately will determine public acceptance of carbon management strategies. CMI will establish which strategies:

- will have the desired effect on atmospheric carbon and climate;
- will be safe and reliable with limited environmental impact;
- will involve neither prohibitive economic costs nor prohibitive disruption of patterns of energy consumption.
Near McElmo Dome, Colorado  (from David Hawkins, NRDC)

“A sign about every quarter-mile” in the Canyons of the Ancients National Monument, Southwest Colorado.
Carbon Mitigation Initiative at Princeton, 2001-2010

Carbon Capture

Carbon Storage

Carbon Science

Carbon Policy

$21,150,000 funding from BP and Ford.
Carbon science

*Carbon science projects* explore the consequences of large-scale carbon management:

- Earth system modeling of the impact of alternative mitigation options on greenhouse gases and climate.

- Analysis of abrupt changes in the carbon and climate system.

- Shipboard measurements of the O$_2$/N$_2$ ratio of air to estimate natural CO$_2$ sequestration by the land biosphere and oceans.
Carbon Science

**Personnel**
- Abic, Baidya Roy,
- Bender
- Cane, Clark,
- Pacala
- Denkenberger, Deutch,
- Sarmiento
- Donner, Fiore, Gloor,
- Sigman
- Haenssen, Jacobson
- Malyshev, Marinoy
- McKinley, Mignone
- Naik, Purves, Reuer
- Roy, Shevliakova
- Schultz, Selzer, Simeon
- Sturtevant, Weaver

**Core Research**
- Calculate Stabilization Emissions
- Measure Natural Sinks
- Predict Future of Natural Sink
- Predict Climate Change Impacts
- Improve Carbon and Climate Models

**Tools**
- Earth System Model
- Inversion Methods
- Automated Trace Gas Samplers

**Scouts**
- Iron Fertilization
- Glacial/Interglacial
- Deep Injection
- Trees and Air Pollution
- Climate Change and Wind Energy
Carbon capture

*Carbon capture projects* explore the hydrogen-plus-electricity economy:

Low-cost routes to hydrogen production from natural gas and coal, with a first focus on membrane reactors.

Infrastructure requirements for hydrogen and carbon dioxide.
Carbon Capture

**Personnel**

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<td>Williams</td>
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**Core Research**

- Synfuels from biomass and coal
- \( \text{H}_2 \) production from fossil fuels with \( \text{CO}_2 \) sequestration (with Milan)
- Polygeneration of electricity, \( \text{H}_2 \), synfuels (with Tsinghua)
- Gas and Wind Synergies
- \( \text{H}_2 \) and \( \text{CO}_2 \) infrastructures (DOE)
- \( \text{H}_2 \) and DME combustion

**Scouts**

- IGCC Commercialization
- Small- vs. Large-scale \( \text{H}_2 \) production
- Pulp Mill Biorefineries

**Milan**: Consonni, Chiesa, Vigano

**Tsinghua**: Li, Ren

**Tools**

- Aspen Plus and GS (Milan): plant design
- Markal: energy forecasting
- Combustion Laboratory
Carbon storage

*Carbon storage projects* explore the safety, reliability and environmental impact of carbon storage in underground reservoirs:

- Predictive models of CO2 leaking from an underground storage site as it moves toward the earth's surface, with an emphasis on chemistry in drinking-water aquifers and the unsaturated zone.
- Experimental studies of the chemistry of CO2 at high pressure.
- Exploratory studies of alternatives to underground storage (e.g., oceanic injection, carbonate production, enhanced biological sequestration).
Carbon Storage

Personnel
Celia Altevogt
Jaffe Bruant
Myneni Duguid
Peters Gasda
Prevost Giammar
Scherer Li
Luet
Rodonjic

Core Research
CO₂ Leakage Estimation
Data from Alberta Basin (with AGS)
Critical Pathway: Existing Wells and Cement
Risks associated with CO₂ leakage into shallow ground water and soils
Geochemistry of CO₂-Brine-Rock Interactions

Tools
Extend Dynaflow geomechanics code to include multi-phase, multi-component flow capabilities
Upscaling of micro-phenomena to large spatial scale

Scouts
Mammoth Mountain field studies of high- CO₂ soil gas impacts on vegetation
Carbon Storage After Fall 2003

Personnel

Celia Altevogt
Scherer Bruant
Prevost Duguid
Gasda Giammar
Li Luet
Rodonjic

Core Research

Potential for CO₂ Leakage From Existing Wells Focusing on Cement

1. Analysis of field collected cement samples (Teapot Dome).
2. Laboratory experiments on cement in the presence of CO₂.
3. Numerical models for the areas surrounding the interface between sequestration reservoir and well.
4. Fast reservoir models for basin scale risk analysis.

Tools

Geochemistry and geomechanics module for CO₂ reservoir/well interface that runs within industry-standard reservoir simulation codes.

Scouts

Mathematics of injected CO₂
Carbon policy

*Carbon policy projects* explore the economics of large-scale sequestration:

The economics of leaky containment and the discounting of future damages.

Incentives bearing on shifts in technological regimes.
Stabilization Wedges: Solving the Climate Problem for the Next 50 Years with Current Technologies

Stephen W. Pacala and Robert Socolow
Science Vol. 305 968-972 August 13, 2004
Carbon Integration

Personnel

Socolow  Li
Pacala  Naevdal
Bradford  Kim
Oppenheimer  Wagner
Donner
Greenblatt
Naik

Core Research

The Wedge Model
Optimal magnitudes and timing of mitigation
Benchmarking “dangerous interference with the climate system”

Scouts

Innovative international allowance trading scheme
Psychology of Climate Change (Workshop, November 2004)
Site-Sensitive Air Pollution Policy

Tools

Modified versions of the RICE MiniCAM (PNL) and Merge (EPRI)

Penn State: Keller