Climate Change Technology Scenarios
Interim Product

July 7, 2003
ASPEN Workshop
Near-term commitment:
Reduce GHG intensity by 18% by 2012.

Long-term commitment:
“I reaffirm America’s commitment to the United Nations Framework Convention and it’s central goal, to stabilize atmospheric greenhouse gas concentrations at a level that will prevent dangerous human interference with the climate.”

—President George W. Bush

Deployment of best available technologies and practices across the Nation

Tremendous breakthroughs in the cost and performance of technology is required:

- Advanced Coal
- Sequestration
- Advanced Gas
- Hydrogen
- Energy Efficiency
- Nuclear
- Renewables

CCTP’s Mission is to coordinate this $1.6B+ Effort
Scale of the Technology Challenge

Global Greenhouse Gas Emissions

Without Technological Change

With Technological Change

Illustrative Stabilization Pathway
## How Big is a Gigaton?

**Assuming Today’s Technology**

<table>
<thead>
<tr>
<th>Today’s Technology</th>
<th>Actions that Provide 1 Gigaton/year of Mitigation</th>
<th>Major Issues</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal Plants</td>
<td>Replace 1,000 conventional 500-MW plants with “zero-emission” power plants</td>
<td>Technical, Social, &amp; Economic Viability</td>
</tr>
<tr>
<td>Geologic Sequestration</td>
<td>Install 3,500 Sleipners, at 1 Mt of CO₂ per year¹</td>
<td>Technical, Social, &amp; Economic Viability</td>
</tr>
<tr>
<td>Nuclear</td>
<td>Build 500 1 GW plants (in lieu of unsequestered coal)</td>
<td>Economics, Safety, Non-proliferation,</td>
</tr>
<tr>
<td>Efficiency</td>
<td>Deploy 1 billion cars at 40 mpg instead of 20 mpg</td>
<td>Distributed opportunity that is hard to capture</td>
</tr>
<tr>
<td>Wind</td>
<td>Install 750 x current U.S. wind generation (in lieu of unsequestered coal)</td>
<td>Geographic Limitations, Storage</td>
</tr>
<tr>
<td>Solar PV</td>
<td>Install 4,500 x current U.S. solar generation (in lieu of unsequestered coal)</td>
<td>Geographic Limitations, Storage</td>
</tr>
<tr>
<td>Biomass fuels from plantations</td>
<td>Convert an area &gt;7.5X the size of Iowa’s farmland to biomass</td>
<td>Land-Use Changes</td>
</tr>
<tr>
<td>Storage in new forest</td>
<td>Convert an area &gt;30X the size of Iowa’s farmland to biomass</td>
<td>Land-Use Changes</td>
</tr>
</tbody>
</table>

Today’s technology simply can’t meet the scale of the challenge.
Scenarios and Strategic Planning

**Technology Scenarios**
- key sector-level transitions
- key technologies
- limits exploration
- cost & performance goals

**Return Analysis**
- Gigatons
- Economic

**Strategic Plan**
- Vision
- Federal priorities
- Program-level priorities

**President’s Budget**
- $1.6B + in FY04
- Specific Programs
- Specific Projects
CCTP Technology Scenarios

Draws on Extensive Previous Studies

- 50 to 100 common scenarios in the energy community

- CCTP seeks to draw insights from existing scenarios and studies

- CCTP scenarios focus on
  - Key Sector-Level Transition
  - Key Technologies
  - Limits Exploration
  - Cost & Performance Goals

Three CCTP Scenarios
Technology Scenario #1: “Closing the Loop on Carbon”

Introduction of Carbon Sequestration and Hydrogen Technologies
Augment the Standard Suite of Energy Technologies

Technology Scenario #2: “A New Energy Backbone”

Major Technological Advances in Renewable and Hydrogen Technologies are Coupled with a New Generation of Nuclear Reactors

Technology Scenario #3: “Beyond the Standard Suite”

Dramatic Breakthroughs in “New and Advanced Technologies – e.g., Fusion, Bio-X” – Create a Fundamentally Changed Energy System
CCTP Technology Scenarios

The Hierarchy

- Scenario Titles
- Bullet Descriptions
- Scenario Summaries
- Key Sector Transitions
- Key Technologies over Time
- Data, Analysis and Characterizations of Key Parameters
“Closing the Loop on Carbon”
Technology Scenario #1

• The Standard Suite of Technologies is Substantially Augmented by Engineered CO$_2$ Sequestration, which Meets Key Technical, Economic, and Environmental Goals

• Fossil-Based Systems (Fuels, Power, Chemicals) Remain the Backbone of the Energy System

• Unconventional Oil & Gas becomes Economically Viable

• Solar, Wind and Bio-Fuels Industries Achieve Maturity

• Hydrogen Becomes a Significant Energy Carrier

• The Full Potential of Conventional Oil & Gas is Realized

• Dramatic Gains in Energy Efficiency Occur

• Other GHGs Successfully Addressed
One Possible Way
“Closing the Loop on Carbon” Might Play Out

NOTE: The Scenarios Can Play Out in Numerous Specific Ways While Maintaining the Same General Characteristics.
“Closing the Loop on Carbon”
Total U.S. Primary Energy + Efficiency/Conservation

Energy Demand in Carbon-Constrained World

Energy Efficiency and Conservation

Carbon-Neutral Energy

Carbon-Emitting Energy

NOTE: The Scenarios Can Play Out in Numerous Specific Ways While Maintaining the Same General Characteristics.
“A New Energy Backbone”
Technology Scenario #2

- Extraordinary Advances in Solar, Wind, and/or Traditional Bio-Energy are Realized
- A New Generation of Economically Competitive, Inherently-Safe Nuclear Fission Power is Accepted by the Global Marketplace
- Sequestration is Limited to Niche Markets Limiting Fossil Fuels
- Together, Renewables and Nuclear Become the New Backbone of the Energy System
- Hydrogen Becomes a Significant Energy Carrier
- The Full Potential of Conventional Oil & Gas is Realized
- Dramatic Gains in Energy Efficiency Occur
- Other GHGs Successfully Addressed
“New Energy Backbone”

Primary Energy by Type

One Possible Way
“A New Energy Backbone”
Might Play Out

NOTE: The Scenarios Can Play Out in Numerous Specific Ways While Maintaining the Same General Characteristics.
“Beyond the Standard Suite”
Technology Scenario #3

• Breakthroughs Allow Increasing Reliance on New Technologies that Go Beyond the Standard Suite, for example:
  • Fusion Power
  • Global Super-Conductivity Power Transmission Grids,
  • Orbiting Solar Power Satellites,
  • An Array of Bio-X Technologies
  • Hydrogen Becomes a Significant Energy Carrier

• The Full Potential of Conventional Oil & Gas is Realized
• Dramatic Gains in Energy Efficiency Occur
• Other GHGs Successfully Addressed
• Sustainable Economic Development and Stabilization Achieved
One Possible Way “Beyond the Standard Suite” Might Play Out

NOTE: The Scenarios Can Play Out in Numerous Specific Ways While Maintaining the Same General Characteristics.
Engineered Sequestration

- IF large-scale deployments MIGHT be required by 2020, it suggests the following:
  - Technology must be technically, economically, and socially acceptable by 2020
  - Likely means:
    - A number of demonstrations have been completed by 2020
    - Experiments have occurred in a diversity of locations/geology
    - Experiments started early enough to generate a long time series of data
    - Global community has been engaged in the dialogue surrounding sequestration.

- R&D implications for today
  - Large-scale experiments/demonstration(s) must start this decade
  - Regional implications of sequestration must be investigated early
  - Global community must be engaged
  - Deployment in 2020 requires significant R&D action and funding now
Summary

“Scenarios Are One Step in a Process”

Technology Scenarios
- key sector-level transitions
- key technologies
- limits exploration
- cost & performance goals

Return Analysis

Strategic Plan

President’s Budget
Climate Change Technology Scenarios

Questions??