

PCAST Study and Roadmapping Activities on Carbon Sequestration

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Science Has Spoken: Global Warming Is a Myth

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Carbon Sequestration R&D is a Kind of Insurance Policy for Dealing with Global Warming

- The premiums are low
- It can be a no-regrets approach
- It is for the public good

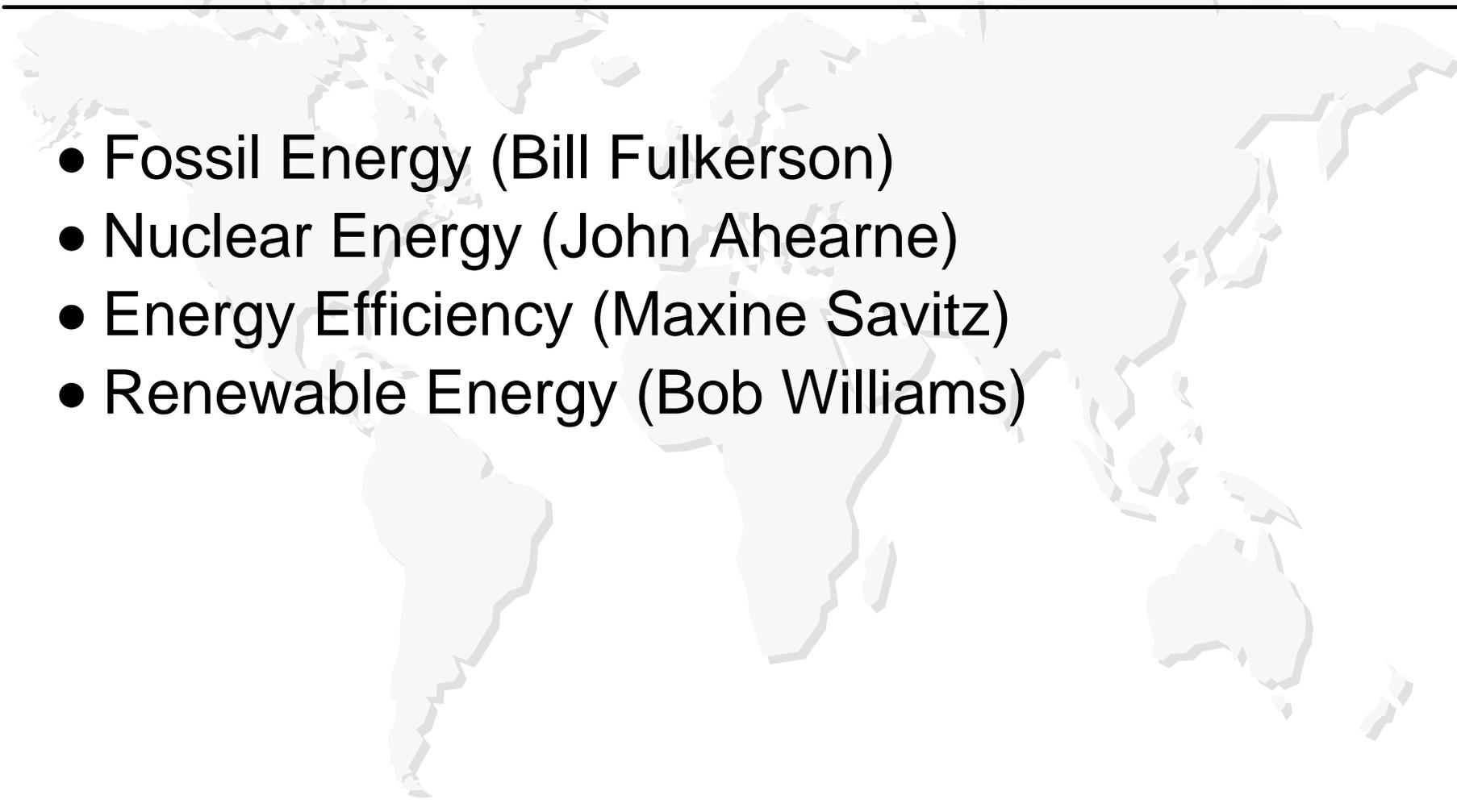
This Presentation is Based on Two Reports

- Federal energy research and development for the challenges of the twenty-first century
 - PCAST
 - Energy research and development panel
- Working paper on carbon sequestration science and technology
 - Leadership by DOE Offices of Fossil Energy and Science

Motivation and Content are Important to Understanding the PCAST Report

- Major challenges to society of the increasing use of fossil fuels
 - Environmental challenges (particularly CO₂ emissions)
 - Vulnerability of U.S. economy to oil price shocks
- Magnitude of fossil fuel use and projections of ever-increasing reliance on fossil fuels
 - 75% of the world's energy systems are fossil fueled
 - Fossil's share in U.S. projected to increase by three percentage points by 2015

The R&D Panel Assessed the R&D Portfolio of DOE's Applied Programs

- Fossil Energy (Bill Fulkerson)
 - Nuclear Energy (John Ahearne)
 - Energy Efficiency (Maxine Savitz)
 - Renewable Energy (Bob Williams)
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PCAST Recommendations for Significant Emphasis Included Five Initiatives and Vision 21

- CO₂ sequestration
- Methane hydrates
- Hydrogen manufacture and infrastructure
- Comprehensive transportation fuels R&D strategy
- Developing country technologies

PCAST Recommended a Major Initiative on Carbon Sequestration

- Enormous and expensive undertaking
- R&D is high risk and long term
- Appropriate for government funding
- Science-based assessment of prospects and costs needed
- R&D supported and managed by FE in collaboration with ER (now SC) and USGS
- International collaboration, particularly with Europe and Japan
- R&D budget of several tens of millions of dollars needed

Our Principal Concern is How to Control Greenhouse Gas Emissions, Particularly CO₂

- CO₂ is the major anthropogenic greenhouse gas
- Fossil fuel burning accounts for more than 75% of the increasing CO₂ in the atmosphere
- Deforestation by slash and burn techniques is the other Major source of CO₂

Most Suggestions About What to do to Head Off the Changing Greenhouse Effect Include Variants on the Same Themes

- Use energy more efficiently (get more energy services with less energy consumption)
- Shift to energy sources or technologies that do not emit CO₂, especially for electricity production because alternatives are available
- Shift to substitutes for CFCs
- Reduce deforestation and improve forest management to maximize removal of CO₂ by photosynthesis
- Reduce emissions of CO₂ from the use of fossil fuels

Moderation of the Emissions of CO₂ From Fossil Fuel Use Depends on Three Strategies

- Substitute high efficiency natural gas technologies for coal wherever practical
- Develop and adopt much more efficient technologies using coal when substitution is not possible
- Recovering and sequestering CO₂ emissions

There are Two Obvious Problems With the Natural Gas for Coal Substitution Strategy

- Resources of natural gas are much smaller than for coal and transportation of natural gas from the point of production to the point of use can be expensive
- Leakage of natural gas from production and transport systems may partially offset the advantage of its use

Improving the Efficiency of Fossil Fuel May be the Least Expensive Path to Reducing CO₂ Emissions

- Technologies for improving fossil fuel use efficiency exist and are often economical even at current fuel prices
- Potential for implementation of more efficient technologies is as large for developing nations as for industrialized nations

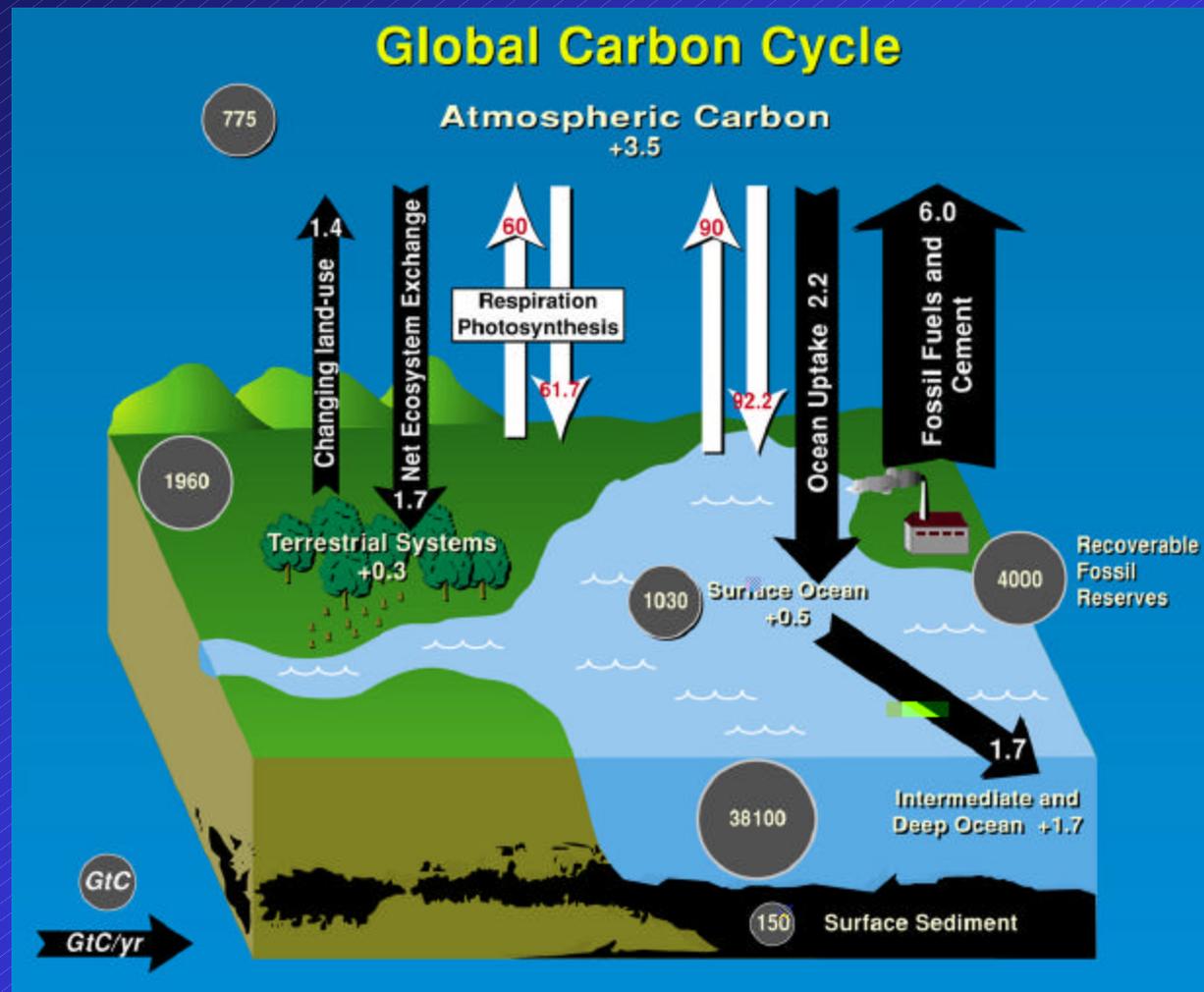
It May be Possible to Capture and Sequester CO₂, But the Methods Proposed Could be Expensive

- Recovery of CO₂ from flue gases
 - Separation and capture processes
 - Combustion with pure oxygen
- Sequestration
 - Deep ocean
 - Depleted gas wells
 - Geologic formations
 - Enhanced terrestrial ecosystems

DOE Working Paper is Responsive to PCAST

- Separation and capture of carbon dioxide
- Ocean sequestration
- Terrestrial ecosystems
- Geologic formations
- Advanced biological processes
- Advanced chemical approaches

Human-induced Changes in the Global Carbon Cycle was the Major Issue Addressed



The Magnitude of the Impact of Carbon Sequestration Appears Huge

- To offset CO₂ emissions from 500 MWe coal-fired power plant operating at 34% efficiency would require:
 - 1000 square miles of new forest
 - 35,000 tons of silicate rock per day
- To sequester the total carbon emissions of the United States would require:
 - 1,000,000 square miles of new forest (this is about 25% of the land area of the United States)
 - 35,000,000 tons of silicate rock per day

The DOE Working Paper Reveals Some Optimism

- Carbon sequestration can provide ancillary benefits
- Some options can work within existing infrastructure; others require a new distribution system
- Government sponsorship of required R&D is appropriate
- Some options are near-term and can be used until new options are developed

Some Estimates of Carbon Sequestration Capacities Were Made

- Oceans - capacity exceeding estimated available fossil fuel resources (5,000-10,000 GtC)
- Terrestrial ecosystems - 5-10 GtC/year
- Geologic formations (U.S.) - 45-175 GtC

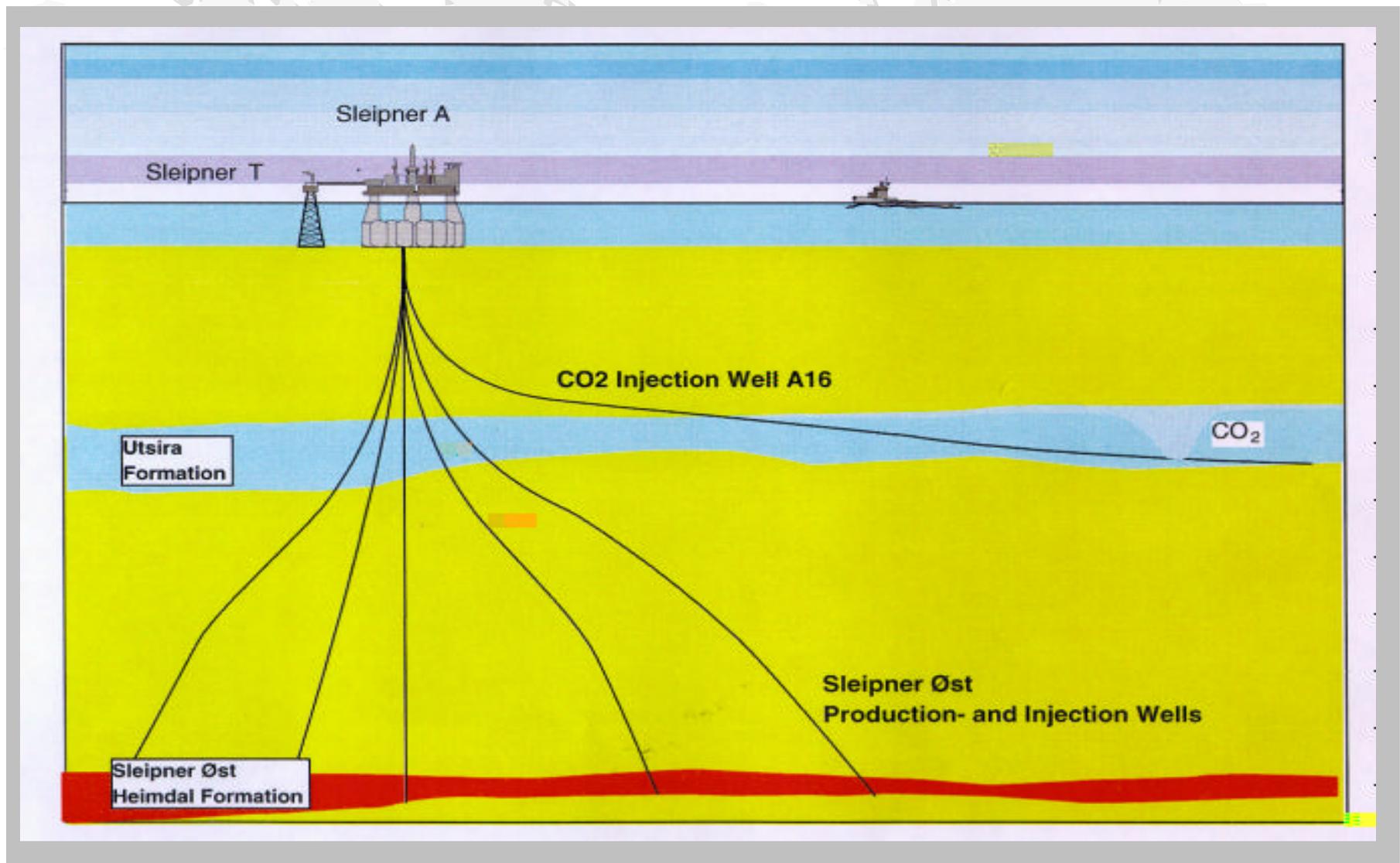
CO₂ Separation is Common in Many Industrial Applications



Statoil Sequesters CO₂ from Offshore Gas Production



Natural Gas From the Sleipner West Field is Transported to Sleipner T (Treatment) Platform and Then to Sleipner A Platform for Injection



Several Broad Recommendations are Provided in the DOE Working Paper

- Ensure that research develops technologies that are cost effective and benign
- Ensure that the research is integrated with other related research programs
- Ensure that research is flexible and targets a wide variety of approaches
- Initiate field-scale investigations
- Ensure that the research program develops an integrated approach to setting priorities and evaluating probabilities of success
- Ensure that results of the R&D program are provided to policy makers

The Development of the Roadmap Should Continue

- Criteria for setting research priorities should include the magnitude of the impact of the carbon sequestration option
- Roadmap should be developed further and refined

