U.S. Climate Change Policy and Technology: An Update

Stephen D. Eule
Director
Climate Change Technology Program
U.S. Department of Energy

Fifth Annual Conference on Carbon Capture and Sequestration

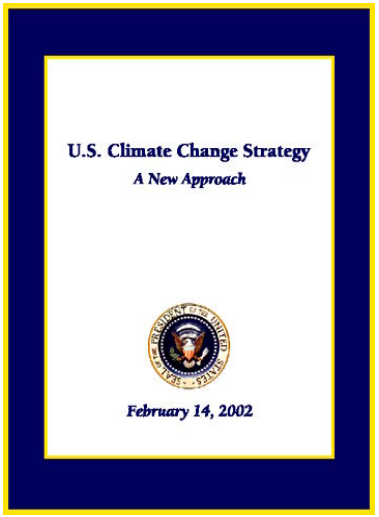
9 May 2006

U.S. Approach

I reaffirm America's commitment to the United Nations Framework Convention and its central goal, to stabilize atmospheric greenhouse gas concentrations at a level that will prevent dangerous human interference with the climate.

President George W. Bush

February 14, 2002



- U.S. approach to climate change harnesses the power of markets and technological innovation, maintains economic growth, and encourages global participation.
- Reaffirms U.S. commitment to goal of UNFCCC.
- Places climate change in a broader development context.
- Four basic elements:
  - near-term policies & measures, including tax incentives;
  - improved climate science;
  - advanced technologies; and
  - international collaboration.

POLICIES & MEASURES TO REDUCE GHG EMISSIONS INTENSITY

Near-Term Goal: Reduce GHG Emissions Intensity

- In February 2002, President Bush set a goal to reduce U.S. GHG emissions intensity—GHG emissions per unit of GDP—18% by 2012.
- Equivalent to ≈500 MM metric tons of cumulative carbon equivalent reductions from 2002 to 2012.
- Policy actions:
  - ✓ Voluntary Programs
    - » Climate VISION
    - » Climate Leaders
    - » SmartWay Transport
    - » 1605(b)
  - ✓ Tax incentives/deployment partnerships
  - ✓ CAFE increase for light trucks
  - ✓ USDA incentives for sequestration
  - ✓ Tropical forest conservation

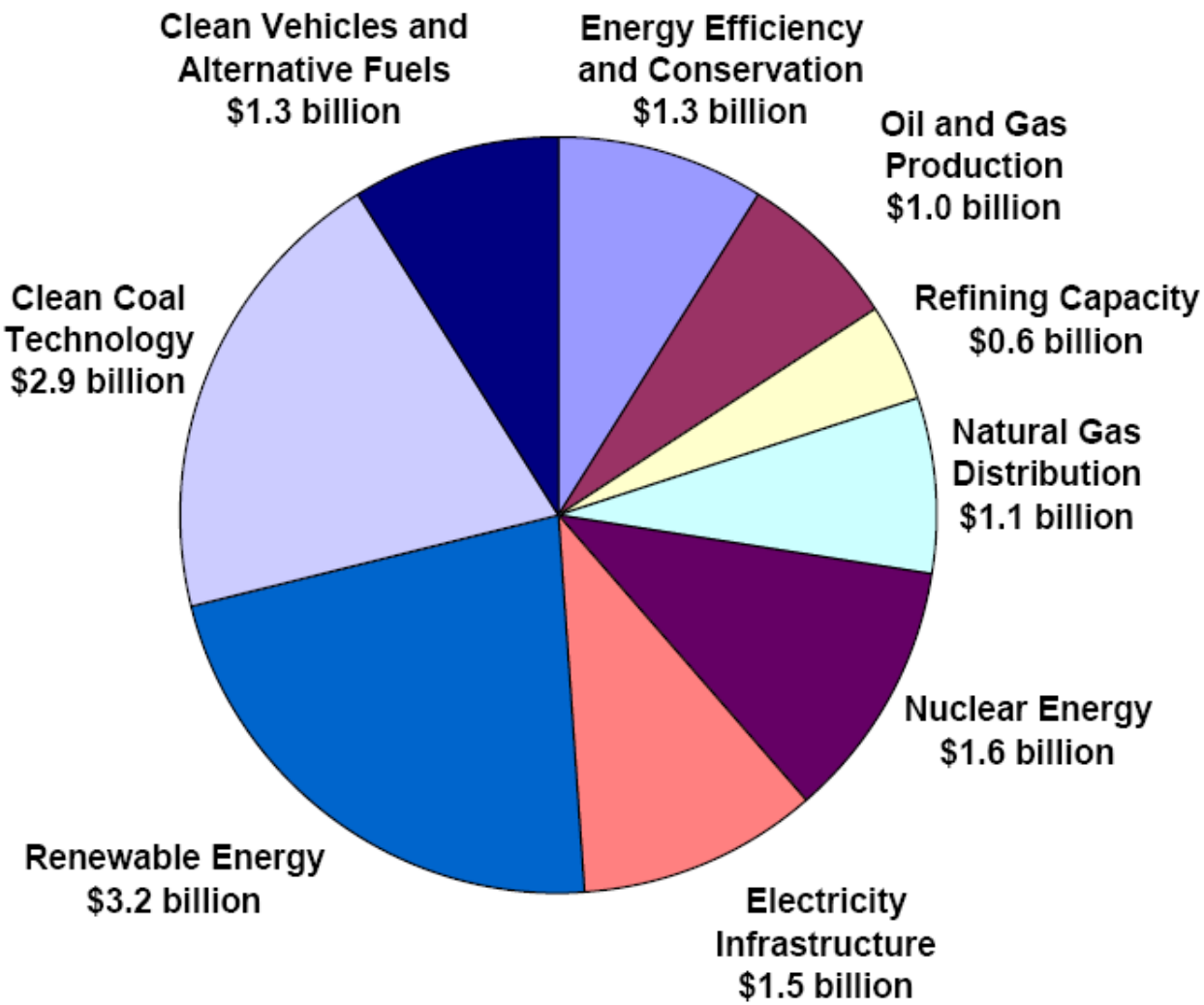
Climate VISION Sectors

- Alliance of Automobile Manufacturers
- Aluminum Association
- American Chemistry Council
- American Forest & Paper Association
- American Iron & Steel Institute
- American Petroleum Institute
- Association of American Railroads
- The Business Roundtable
- Industrial Minerals Association - North America
- International Magnesium Association
- National Lime Association
- National Mining Association
- Portland Cement Association
- Power Partners
- Semiconductor Industry Association

Voluntary Reporting of Greenhouse Gases

- Program established by section 1605(b) of the EPAct 1992.
- Over 200 regular reporters from utilities, landfills, small businesses, etc.
- President directed update to improve “enhance measurement accuracy, reliability and verifiability.”
- Interim Final Guidelines issued in November 2005.
- Final Guidelines released in April 2006. Will encourage comprehensive, entity-wide reporting.
- Reporting begins under new system in 2007.
- For more information, please visit: http://www.pi.energy.gov/enhancingGHGregistry

EPAct 2005: Deployment Tax Incentives



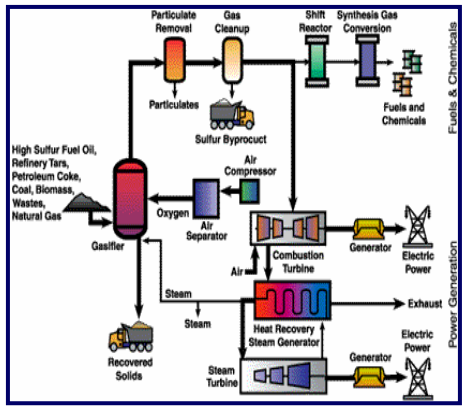
Incentives: $14.5 billion

Offsets: $3 billion

Total: $11.5 billion

EPAct2005: Incentives for Innovative Technologies

- **Title XVII** authorizes DOE to issue loan guarantees of up to 80% of project costs to accelerate commercial deployment of advanced energy technologies.
  - Eligible technologies must:
    - ✓ Avoid, reduce or sequester GHG or air pollutants
    - ✓ Employ new or significantly improved technology
  - Technology categories include:
    - ✓ Renewables
    - ✓ Carbon capture & storage
    - ✓ Hydrogen fuel cells
    - ✓ Advanced nuclear energy
    - ✓ Coal gasification
    - ✓ Energy efficiency
    - ✓ Efficient generation and T&D
    - ✓ Production facilities for fuel efficient vehicles



Gasifier

- **Title XV** increases the amount of the renewable content of gasoline from 4.0 billion gallons in 2006 to 7.5 billion gallons in 2012.
- **Title VI** provides standby support coverage for certain regulatory delays for up to 6 new nuclear plants.

ADVANCING CLIMATE CHANGE SCIENCE

Cabinet-Level Engagement

Office of the President

Climate Change Policy and Program Review
by NSC, DPC, NEC

Committee on Climate Change Science and Technology Integration

Chair: Secretary of Energy* Co-Chair: Secretary of Commerce*
Executive Director: OSTP Director

Secretary of State	NEC Director	Secretary of Transportation
Secretary of Agriculture	NASA Administrator	Secretary of Defense
EPA Administrator	Secretary of the Interior	CEQ Chairman
OMB Director	Secretary of HHS	NSF Director

Interagency Working Group on Climate Change Science and Technology

Chair: Deputy/Under Secretary of Commerce*
Chair: Deputy/Under Secretary of Energy
Executive Secretary: OSTP Associate Director for Science

Members DS/US Level:
CEQ, DOD, DOI, DOS, DOT, EPA,
HHS, NASA, NEC, NSF, OMB, USDA

Climate Change Science Program

Director: Assistant Secretary of Commerce
For Oceans and Atmosphere
Members:**
DOC, DOD, DOE, DOI, DOS, DOT, EPA, HHS,
NASA, NSF, Smithsonian, USAID, USDA

Climate Change Technology Program

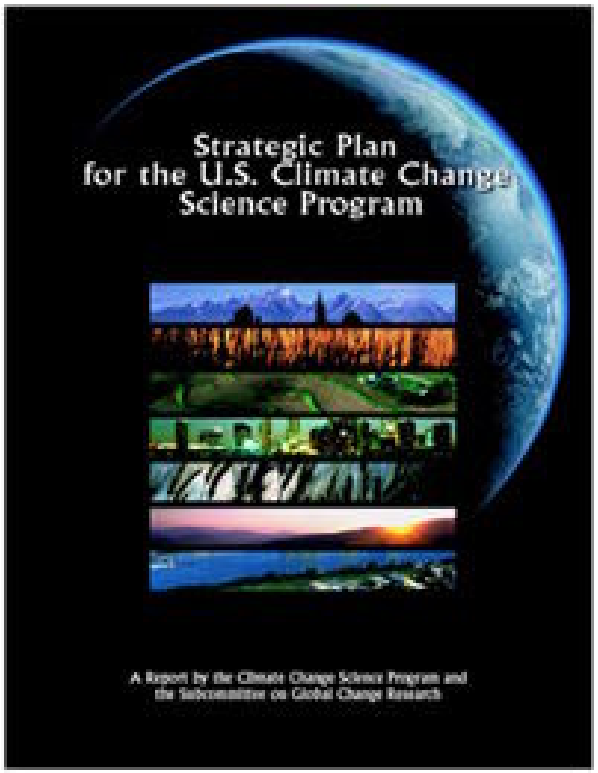
Director: Senior Official
U.S. Department of Energy
Members:**
DOC, DOD, DOE, DOI, DOS, DOT, EPA, HHS,
NASA, NSF, USAID, USDA

* Chair and Vice Chair of Committee and Working Group alternate annually.

** CEQ, OSTP, and OMB also Participate

Climate Science: An Ambitious Plan

- ≈$2 billion/year
- Climate Change Science Program (CCSP) is organized around 5 goals:
  - ✓ Improve understanding of climate history & variability.
  - ✓ Improve ability to quantify factors affecting climate.
  - ✓ Reduce uncertainties in climate projections.
  - ✓ Improve understanding of climate sensitivity to human-induced changes.
  - ✓ Explore options to manage risks.



www.climatescience.gov

Climate Science: Understanding the Risks

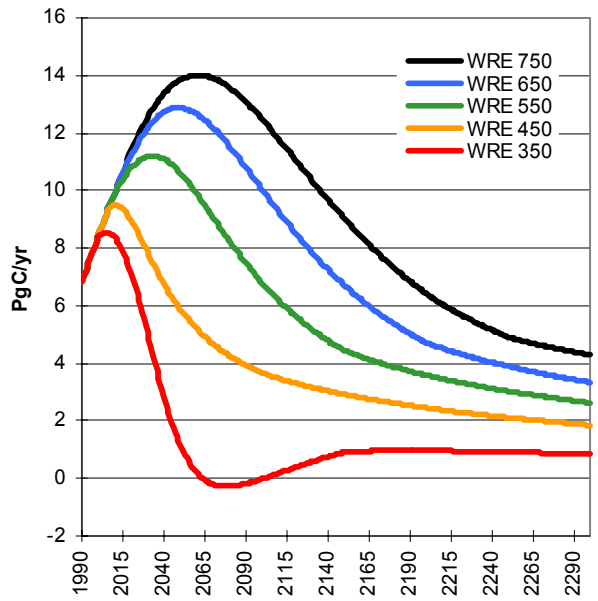
- 21 Synthesis & Assessment Products
  - Temperature trends in the lower atmosphere.
  - Aerosols properties & impacts.
  - Risks of abrupt changes.
  - Ecosystem changes and climate change.
  - Scientific uncertainty and decision support.

ACCELERATING CLIMATE CHANGE TECHNOLOGIES

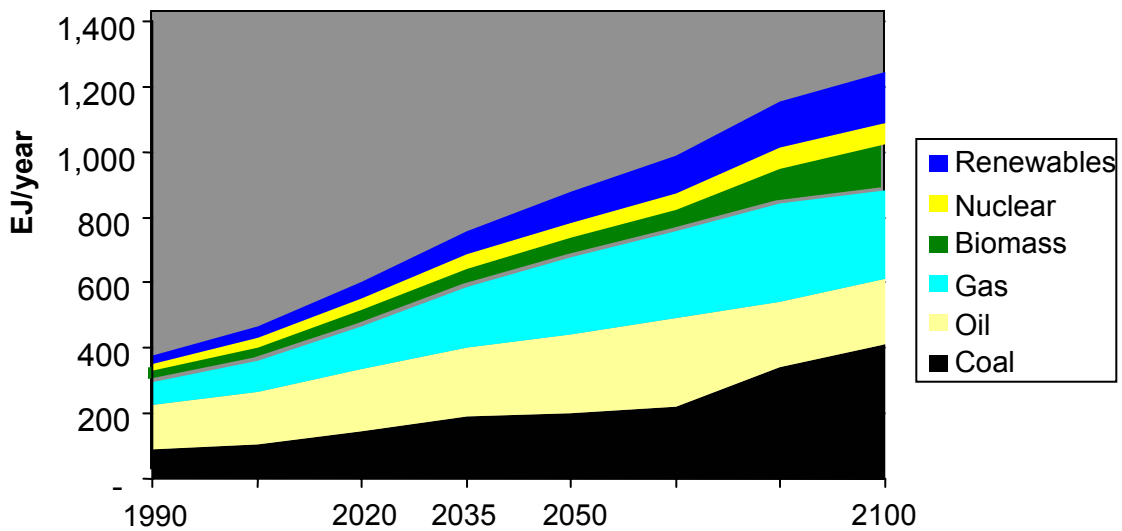
Climate Change Technology: Meeting the Long-Term Challenge

To provide the energy for continued economic growth and development while we reduce greenhouse gas emissions, we will have to develop cost-effective technologies that alter the way we produce and use energy.

Stabilization Curves

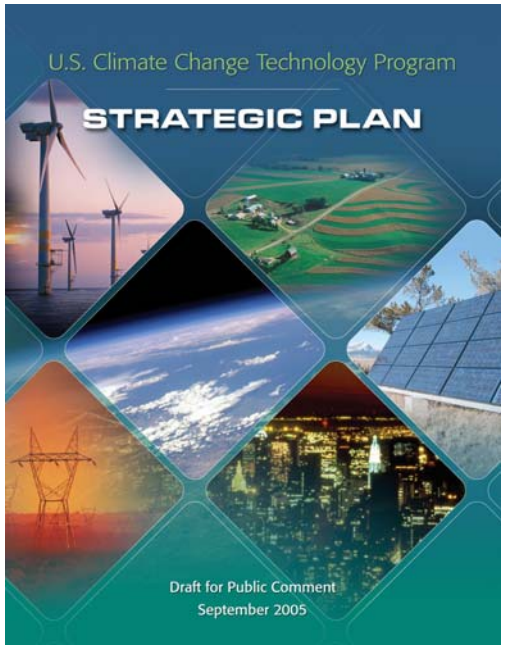


World Primary Energy Demand, 1990-2100: Reference Case



Technology: Seeking Better and More Cost-Effective Solutions

- U.S. Climate Change Technology Program
  - ✓ An ambitious program of RDD&D
  - ✓ ≈$3 billion/year
- Climate Technology Goals:
  - ✓ Reduce Emissions From Energy End Use & Infrastructure
  - ✓ Reduce Emissions From Energy Supply
  - ✓ Capture & Sequester CO_2
  - ✓ Reduce Emissions From Non-CO_2 Gases
  - ✓ Improve Capabilities to Measure & Monitor GHG
  - ✓ Bolster Basic Science
- CCTP authorized in *EPAct2005*.



www.climatetechnology.gov

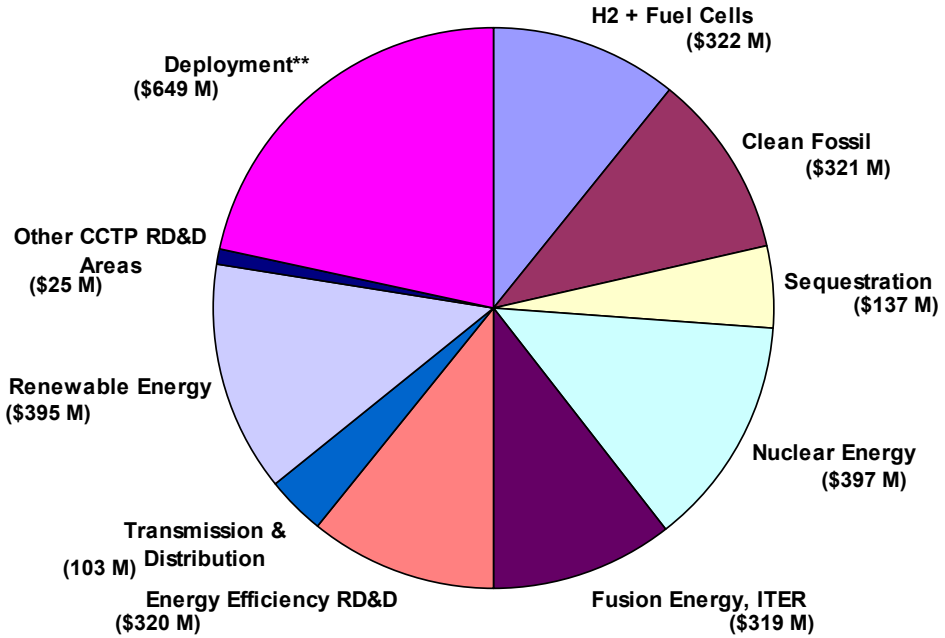
Roadmap for Climate Change Technology Development

	Near-Term	Mid-Term	Long-Term
Goal 1: Energy End-Use & Infrastructure	• Hybrid & Plug-In Hybrid Electric Vehicles • Engineered Urban Designs • Net-Zero Energy Homes • High Efficiency Appliances • High Efficiency Boilers & Combustion Systems • High-Temperature Superconductivity Demonstrations	• Fuel Cell Vehicles and H_2 Fuels • Low Emission Aircraft • Solid-State Lighting • Ultra-Efficient HVACR • Net-Zero Energy Buildings • Transformational Technologies for Energy-Intensive Industries • Energy Storage for Load Leveling	• Widespread Use of Engineered Urban Designs $ Regional Planning • Net-Zero Energy Communities • Integration of Industrial Heat, Power, Process, and Techniques • Superconducting Transmission and Equipment
Goal 2: Energy Supply	• IGCC Commercialization • Stationary H_2 Fuel Cells • Cost-Competitive Solar PV • Demonstrations of Cellulosic Ethanol • Distributed Electric Generation • Advanced Fission Reactor and Fuel Cycle Technology	• FutureGen Scale-Up • H_2 Co-Production from Coal/Biomass • Low-Speed Wind Power • Advanced Biorefineries • Community-Scale Solar • Gen IV Nuclear Plants	• Zero-Emission Fossil Energy • H_2 & Electric Economy • Widespread Renewable Energy • Bio-Inspired Energy & Fuels • Widespread Nuclear Power • Demonstration of 500 MW Fusion Plant
Goal 3: Capture, Storage & Sequestration	• CSLF & CSRP • Post Combustion Capture • Oxy-Fuel Combustion • Enhanced Hydrocarbon Recovery • Geologic Reservoir Characterization • Soils Conservation • Dilution of Direct Injected CO_2	• Geologic Storage Proven Safe • CO_2 Transport Infrastructure • Soils Uptake & Land Use • Ocean CO_2 Biological Impacts Addressed	• Track Record of Successful CO_2 Storage Experience • Large-Scale Sequestration • Carbon & CO_2 Based Products & Materials • Safe Long-Term Ocean Storage
Goal 4: Other Gases	• Methane to Markets • Precision Agriculture • Advanced Refrigeration Technologies • PM Control Technologies for Vehicles	• Advanced LFG Utilization • Soil Microbial Processes • Substitutes for SF_6 • Catalysts That Reduce N_2O to Elemental Nitrogen in Diesel Engines	• Integrated WM System with Automated Sorting, Processing & Recycle • Zero-Emission Agriculture • Solid-State Refrigeration/AC Systems
Goal 5: Measure & Monitor	• Low-Cost Sensors and Communications	• Large Scale, Secure Data Storage System • Direct Measurement to Replace Proxies and Estimators	• Fully Operational Integrated MM Systems Architecture (Sensors, Indicators, Data Visualization and Storage, Models)

FY 2007 Budget Request -- CCTP Portfolio

Total Multi-Agency FY07 Budget Request: $ 2,987 Million

CCTP FY07 Budget Request* Portfolio of RD&D and Deployment



* All CCTP Federal Agencies FY07 Budget Request

** Deployment is 79% Energy Efficiency

Hydrogen Fuel Initiative

Renewable

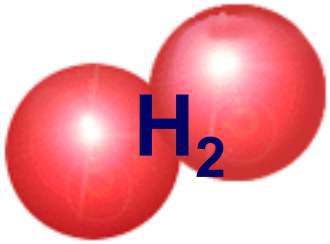
- Biomass
- Hydro
- Wind
- Solar

Non-Renewable

- Nuclear
- Oil
- Coal
- Natural Gas

Sequestration

HIGH EFFICIENCY & RELIABILITY



ZERO/NEAR ZERO EMISSIONS

Transportation

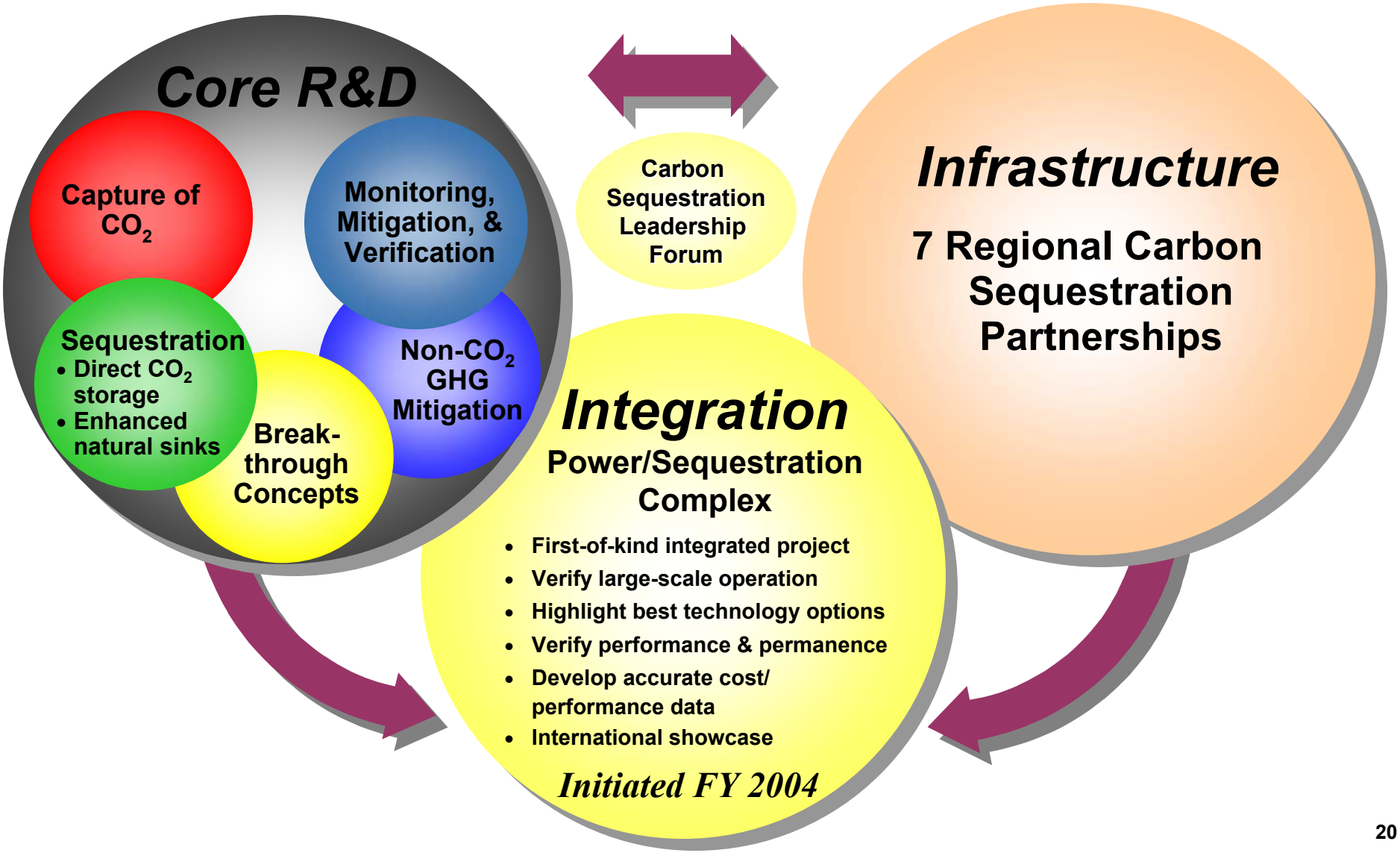
Distributed Generation

Hydrogen Fuel Initiative

- Hydrogen R&D activities: Focused hydrogen program.
  - Will integrate technologies for:
    - ✓ **Hydrogen production** from fossil, nuclear, and renewable resources.
    - ✓ **Infrastructure development**, including delivery and storage.
    - ✓ **Fuel cells** for stationary and transportation applications.

- Technical milestones on the road to a hydrogen economy.

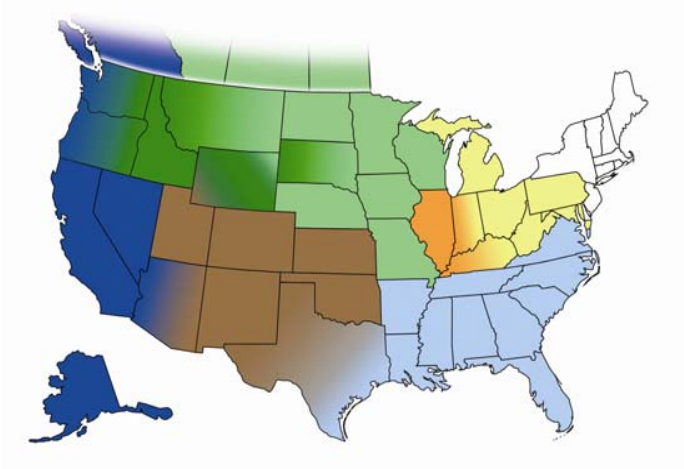
Carbon Sequestration



Regional Sequestration Partnerships: A Phased Approach

Phase I (Characterization)

- 7 Regional Partnerships (40 states & over 200 organizations)
- 24 months (2003-2005)



Regional Partnerships

Phase II (Field Validation Tests)

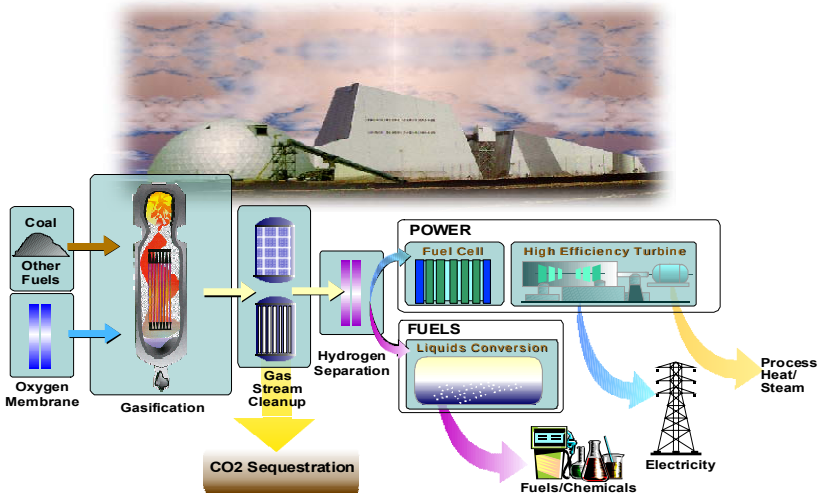
- 4 years (2005 - 2009)
- All seven Phase I partnerships continued
- $100 million federal funds
- $45 million in cost share

Phase III (MMV & Integration)

- 2009-2013
- Significance to FutureGen and public policy

FutureGen

- A U.S.-led, 10-year, ≈$1 billion effort to pioneer coal-to-hydrogen and carbon management technologies for coal.
- FutureGen will be the world's first zero-emission power plant and an international test facility that:
  - Pioneers advanced hydrogen production from coal.
  - Emits virtually no air pollutants.
  - Captures and permanently sequesters carbon dioxide.



- DOE to share project costs with the private sector; FutureGen Alliance has pledged $250MM.
- India and South Korea have joined Government Steering Committee.

Nuclear Power

Nuclear Power 2010: Goals are to:

- identify sites for new nuclear power plants;
- develop and bring to market advanced nuclear plant technologies;
- evaluate the business case for building new nuclear power plants; and
- demonstrate untested regulatory processes.

Advanced Fuel Cycle Initiative: Develop advanced, proliferation resistant nuclear fuel technologies that maximize the energy produced from nuclear fuel while minimizing wastes.

Generation IV Nuclear Energy Systems Initiative: R&D into the next generation of nuclear power plants that are safe, economical, secure, and proliferation resistant.

Nuclear Hydrogen Initiative: R&D into technologies that use nuclear reactors to produce hydrogen, including thermochemical water-splitting cycles, high-temperature electrolysis, and alternative technologies.

Generation IV Nuclear Power

Goal: Gen IV nuclear energy systems deployable no later than 2030 for generation of electricity and other energy products.

The Evolution of Nuclear Power

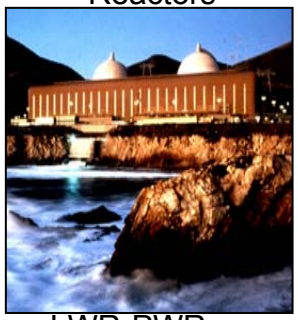
Generation I

Early Prototype Reactors

- Shippingport
- Dresden, Fermi
- Magnox

Generation II

Commercial Power Reactors



- LWR-PWR, BWR
- CANDU
- VVER/RBMK
- AGR

Generation III

Advanced LWRs

- ABWR
- System 80+
- AP600
- EPR

Generation III+

Generation III Evolutionary Designs Offering Improved Economics

Generation IV

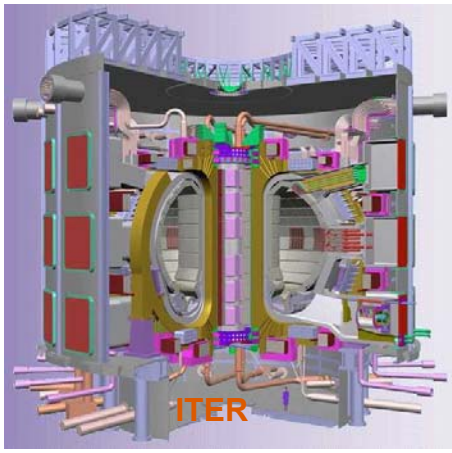
- Highly Economical
- Enhanced Safety
- Minimize Wastes
- Proliferation Resistant

Gen I	Gen II	Gen III	Gen III+	Gen IV

1950 1960 1970 1980 1990 2000 2010 2020 2030

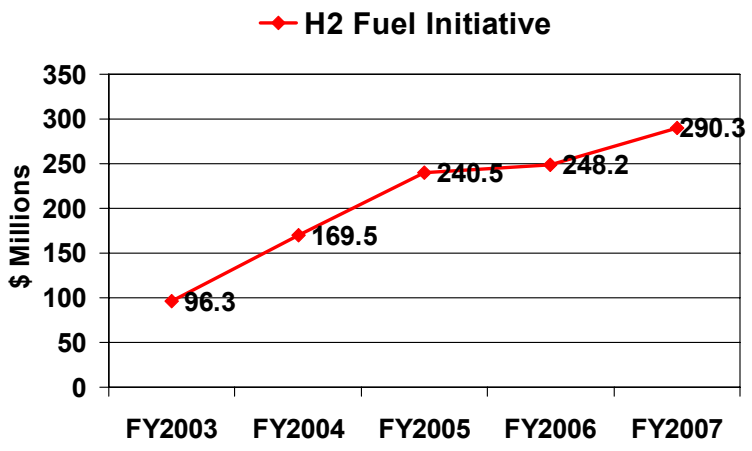
ITER Fusion Energy Project

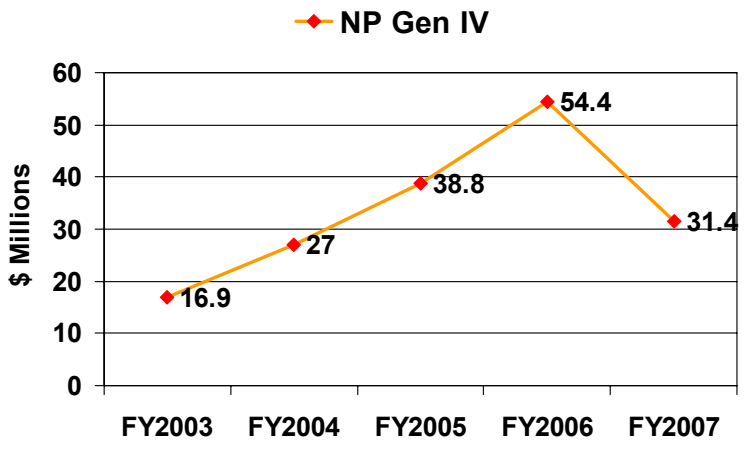
- A proposed multilateral collaborative project between the U.S., China, E.U., Japan, Russia, and Republic of Korea to design and demonstrate a fusion energy production system.
- Updates:
  - ITER site has now been chosen: Cadarache, France, EU.
  - Director General nominee from Japan has been chosen.
  - India recently accepted as 7th Party.
  - Considerable progress has been made toward an international agreement to build and operate ITER; solution in-principle found for virtually all issues.

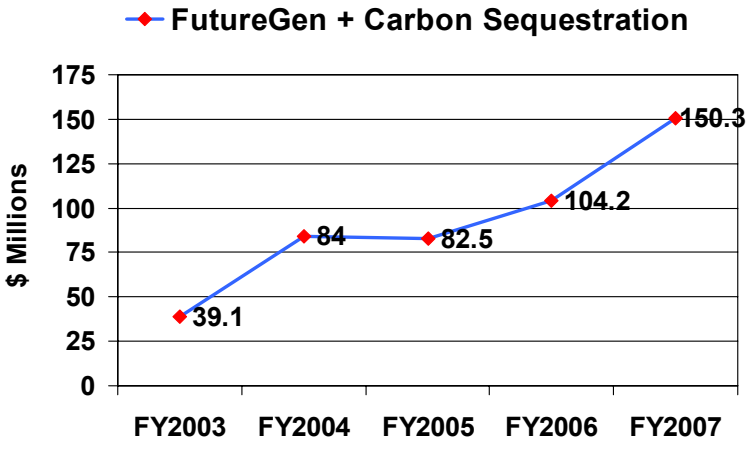


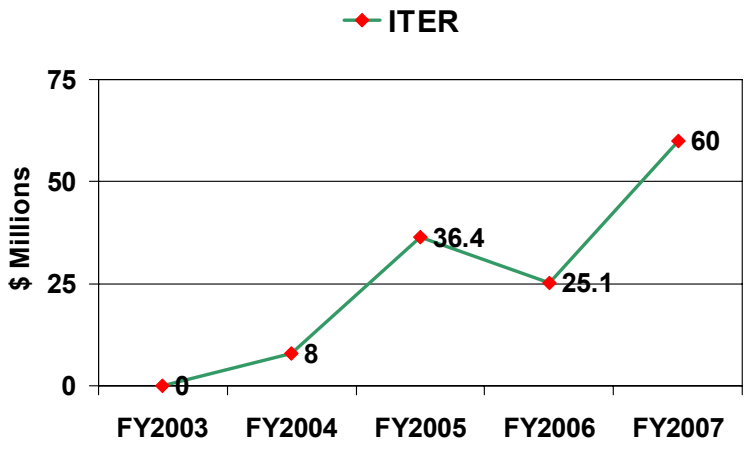
http://www.iter.org

FY 2007 Budget Request – Key Initiatives





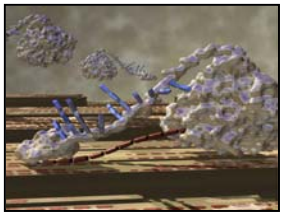




New Initiatives for FY07

Advanced Energy Initiative

- Alter the way we power our homes and automobiles within 20 years.
- DOE FY07 request includes:
  - Solar America Initiative, $148MM (+$65MM vs. FY06)
  - Biomass/Biofuels Initiative, $150MM (+$59MM vs. FY06)
  - Hydrogen Fuel Initiative, $289MM (+$53MM vs. FY06)
  - FutureGen, $54MM ($203MM in FY08)
  - Nuclear Power 2010, $54MM



Global Nuclear Energy Partnership

- Responds to the challenges of:
  - Global terrorism – threat of nuclear proliferation
  - Anticipated 50% growth in electricity demand by 2025
  - Nuclear waste
- DOE request includes $250MM for this initiative.

American Competitiveness Initiative

- President's commitment to double Federal spending on science over the next 10 years
- DOE request includes $4.1 billion (+$505 MM) for the Office of Science

Technology Scenarios Explore the Future

Technology Scenario #1: "Closing the Loop on Carbon"

Advanced Coal, Gasification, Carbon Capture, Sequestration, and Hydrogen Technologies Augment the Standard Suite of Technologies

Technology Scenario #2: "A New Energy Backbone"

Technological Advances in Renewable Energy and Nuclear Power Give Rise New Competitive Realities, Reducing Dominant Role of Fossil Fuels

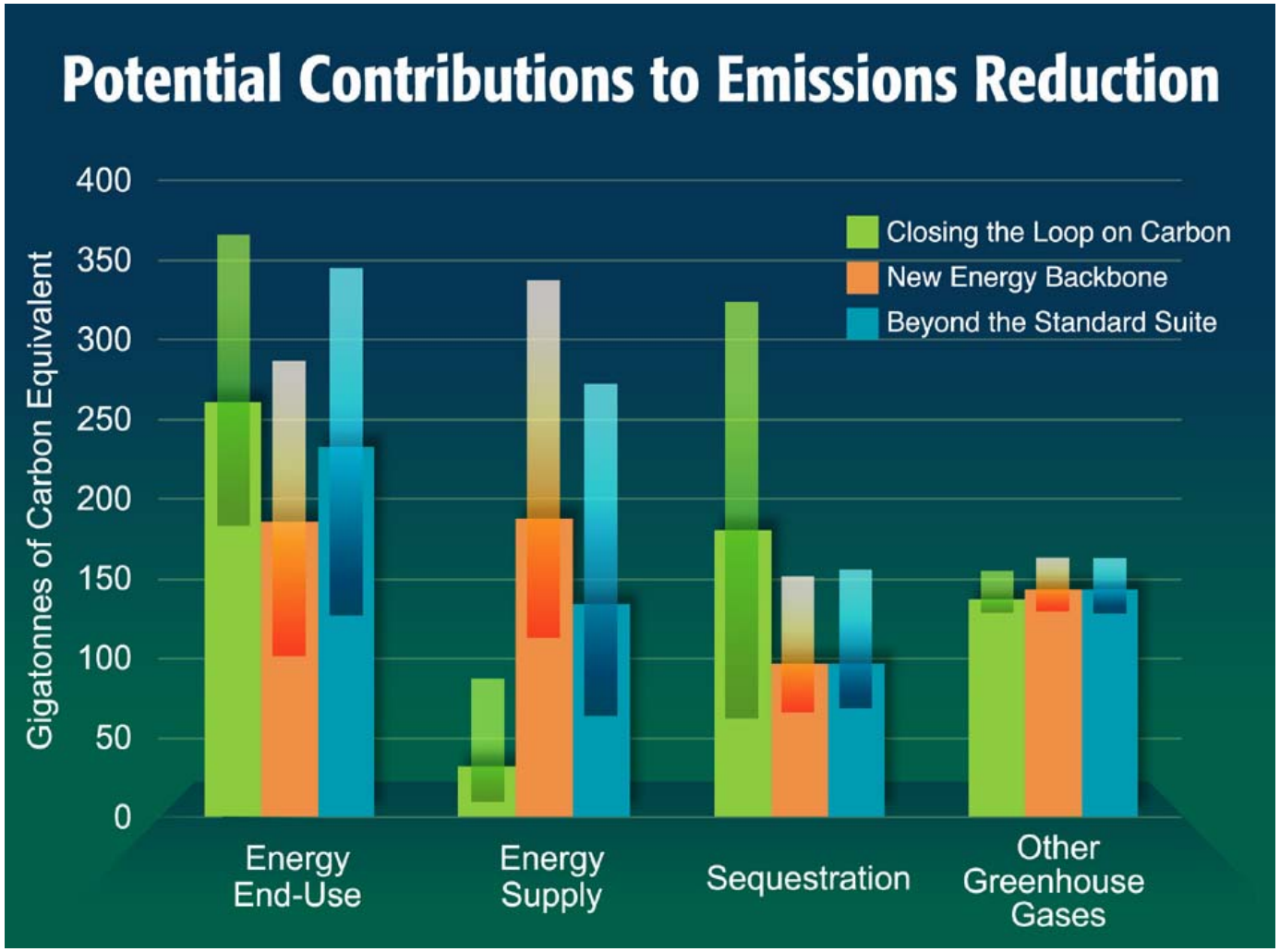
Technology Scenario #3: "Beyond the Standard Suite"

Novel and Advanced Technologies (e.g., Fusion, Large Scale Solar, and Bio-X) Emerge to Play Major Roles, Complementing the Standard Suite.

Common Characteristics Across Scenarios:

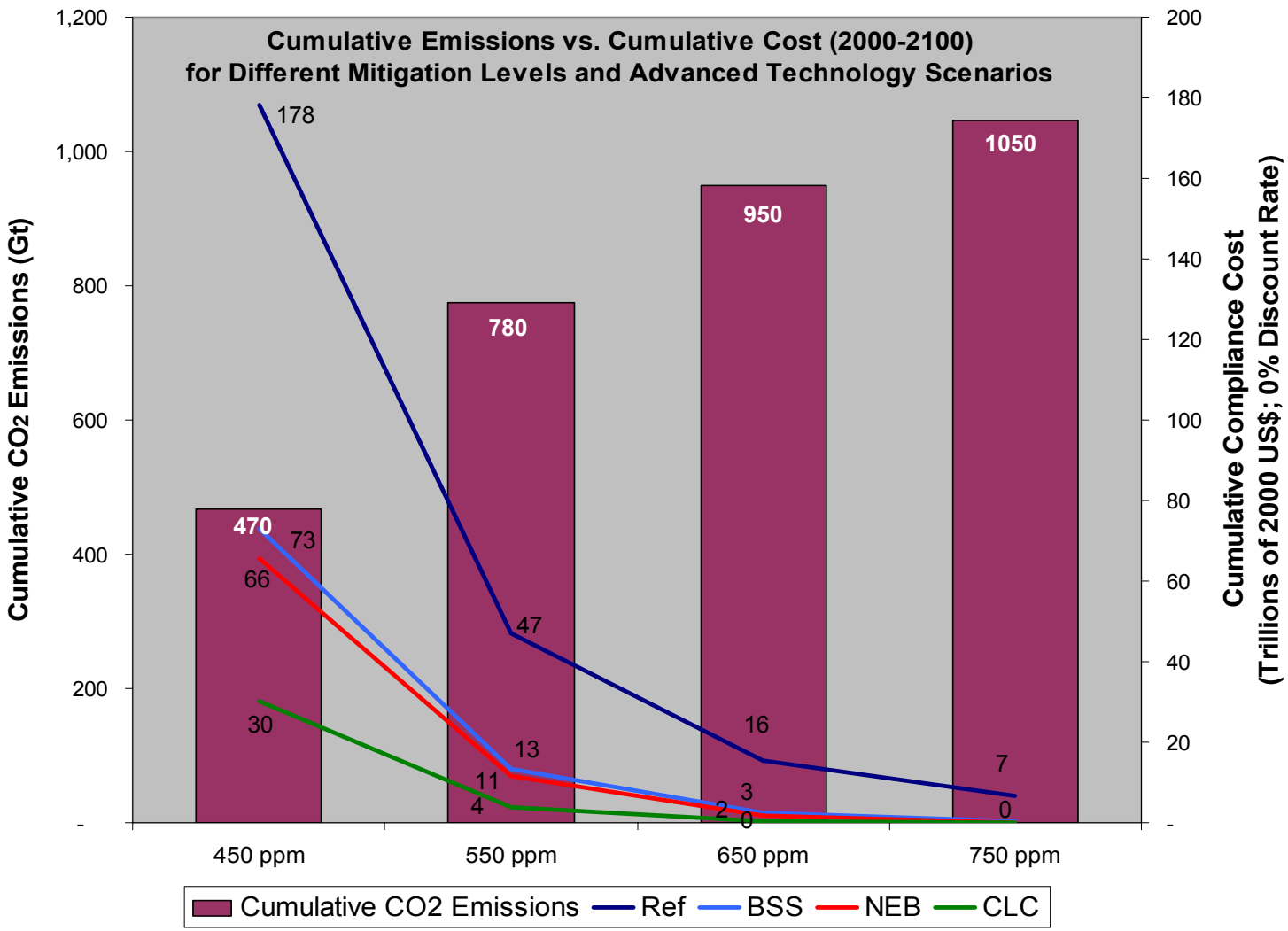
- ✓ *Hydrogen and Liquid Biofuels Become Significant Energy Carriers*
- ✓ *The Full Potential of Conventional Oil & Gas is Realized*
- ✓ *Dramatic Gains in Energy Efficiency Occur*
- ✓ *Successful Management of other GHGs*
- ✓ *Early Market Penetration of Low-Cost Terrestrial Sequestration*

Integrated Results



Source: Placet M; Humphreys, KK; Mahasenan, NM. *Climate Change Technology Scenarios: Energy, Emissions and Economic Implications*. Pacific Northwest Nation Laboratory, PNL-14800, August 2004. Available at: http://www.pnl.gov/energy/climatetechnology.stm

Expected Benefits of Advanced Technology Development



INTERNATIONAL COLLABORATION

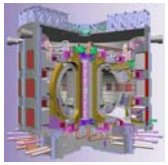
U.S. Climate Change Bilaterals

Innovative International Partnerships

Carbon Sequestration Leadership Forum: 22 members; focused on CO_2 capture & storage.

International Partnership for the Hydrogen Economy: 17 members; organizes, coordinates, and leverages hydrogen RD&D programs.

Generation IV International Forum: 10 members; devoted to R&D on next generation of nuclear systems.



ITER: 6 members; project to develop fusion as a commercial energy source.

Methane to Markets: 17 members; recovery and use of methane from landfills, mines, oil & gas systems, and agriculture.

Asia-Pacific Partnership on Clean Development & Climate: 6 members; focuses on accelerating deployment of technologies to address energy security, air pollution, and climate change.

A Path Forward Involves …

- Near-term actions – through partnerships, voluntary action, and financial incentives.
- Progress in climate change science – to reduce uncertainty.
- Progress in climate change technology will:
  - create new, better, and cheaper solutions
  - facilitate means for change and a smooth transition
- Expanded opportunities for cooperation among:
  - business, industry, States and NGOs
  - research institutions and academia
  - multilateral collaboration