U.S. Approach to Climate Change

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Hydrogen and Fuel Cell Technology Advisory Committee
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Overview

U.S. Approach to Climate Change

Advanced Technology Scenario Analysis

Technology R&D Portfolio Analysis

Supporting Policy and Measures

International Cooperation

Path Forward

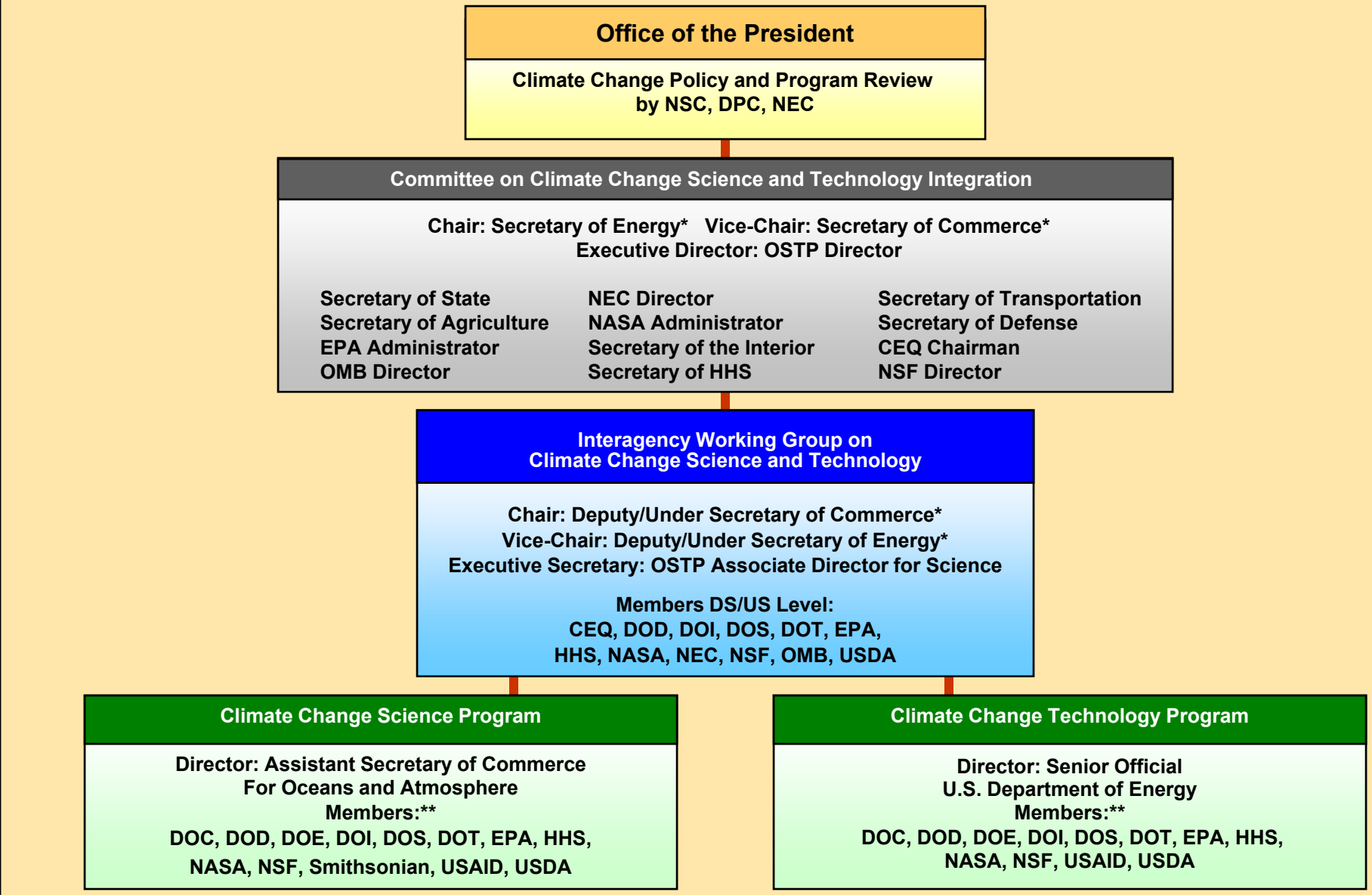
U.S. Approach

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 context that includes:
  - enhancing energy security,
  - encouraging economic growth, and
  - reducing air pollution
- Four basic elements:
  - near-term policies & measures, including financial incentives;
  - improved climate science;
  - advanced technologies; and
  - international cooperation.

Cabinet-Level Engagement



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

** CEQ, OSTP, and OMB also Participate

Near-Term Actions . . .

Voluntary Programs

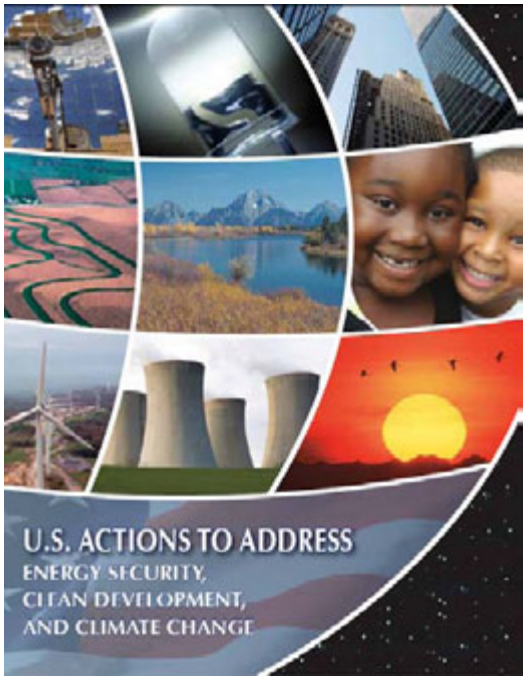
- Climate Leaders
- Climate VISION
- SmartWay Transport Partnership
- Voluntary GHG Emission Registry "EPACT 1605(b)"
- Green Power Partnership (EPA)

Incentives for Investment

- Tax incentives for Conservation, Energy Efficiency, Renewable Energy, & Alternative Fuel Vehicles
- Incentives for Agricultural GHG Sequestration
- USAID's Global Climate Change Program
- Global Environmental Facility Fund
- Tropical Forest Conservation Act

Regulatory Reforms

- CAFE Increased for Light Trucks
- "Twenty in Ten" *



http://www.state.gov/g/oes/climate/

* Initiative to reduce gasoline consumption by 20% by 2017 (Combination of Biofuels and CAFE Standards)

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

Financial Incentives for Investment . . .

Over $3 Billion/Year in Existing Tax Incentives	$M / Year
• Renewable Energy Production Credits **	355
• Residential Solar Energy Systems (Tax Credit)**	10
• Hybrid and Fuel Cell Vehicles (Tax Credit)**	316
• Industry for Landfill Gas and Combined Heat and Power **	133
• Biofuels, Coal Bed Methane (Production Credit) *	1,000
• Biomass Ethanol (Exemption from Excise Taxes) *	1,100
• Hydroelectric, Biomass Elec. (Excl. of Interest on Bonds) *	100
• Clean Fuel Cars, Truck and Refueling Stations *	50
• Investment Tax Credits for Solar, Geothermal Facilities *	50
• Total	3,114

* Congressional Research Service Analysis of Tax Expenditures for 2003

** Fed. Climate Change Expenditures Report, FY 2004

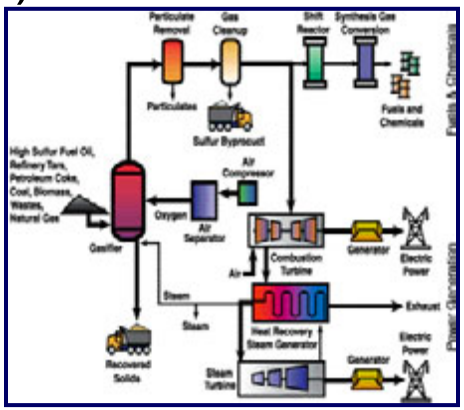
Additional Financial Incentives in EPACT*
2005-2015 ($ Millions)

	10-Years
Renewable Energy	
– Extend Renewable Electricity Production Credit	2,747
– Renewable Energy Bonds	411
– Renewable Content in Gasoline (7.5 Bgal – 2012)	
Nuclear	
– Production Credit for Advanced Nuclear	278
– Nuclear Decommissioning	1,293
– Risk Insurance	2,000
Fossil	
– Investment in Clean Coal Facilities, Including IGCC	1,612
Energy Infrastructure (Transmission)	1,549
Conservation and Energy Efficiency	1,284
Alternative Motor Vehicles and Fuels	1,318
Loan Guarantees for Clean Energy	2,000

* EPACT: Energy Policy Act of 2005

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. (19 full applications requested)
  - Eligible technologies must:
    - ✓ Avoid, reduce or sequester GHG or air pollutants
    - ✓ Employ new or significantly improved technology
  - Requested Advanced Energy Project Categories:
    - ✓ Fossil Energy
    - ✓ Industrial Energy Efficiency
    - ✓ Solar Energy
    - ✓ Electricity Delivery & Energy Reliability
    - ✓ Hydrogen
    - ✓ Biomass
    - ✓ Alternative Fuel 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, and 250 MM gallons of cellulosic ethanol in 2013.
- **Title VI** provides standby support coverage for certain regulatory delays for up to 6 new nuclear plants.

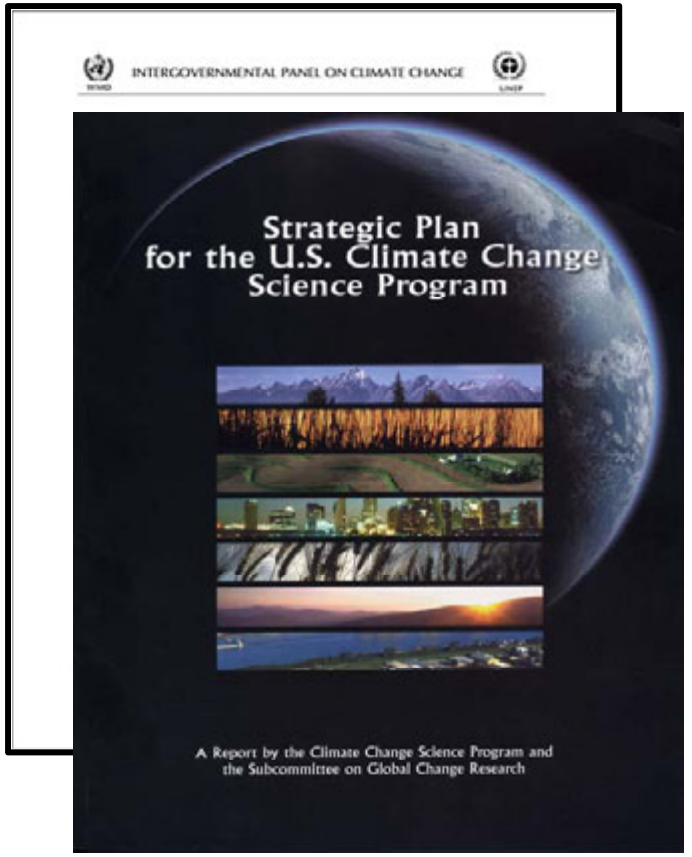
Insights from Climate Change Science

U.S. Climate Change Science Program
- An Ambitious Program of Research ($2 B/Year

Science Has Deepened Understanding:
- Reduced Uncertainties
- Helped Identify & Clarify Risks
- Added Info With Regional Specificity
  - » Water » Big Ice
  - » Coasts » Sea Level Rise
  - » Food » Ecosystems
  - » Health » Ocean Acidification

Growing Awareness of Realities:
- Uneven Responses Internationally
- Conditional Participation by Third World
- Shadow Price of Avoided Emissions High
- Pros & Cons of EU Trading System

Underscored Need for Ambitious Goals for Technology and Accelerated Development



President's Technology Strategy

"Energy security and climate change are two of the great challenges of our time. These challenges share a common solution: technology."

President George W. Bush
Major Economies Meeting
September 28, 2007

Harness the Power of Technology to Meet Energy Needs and Address Climate Change

Key Technology Elements

- **Coal -- De-Carbonize the Grid**
  - » **Nuclear Power**
  - » **Low-Emission Coal Power**
  - » **Renewable Power**
- **Cars -- Transform Cars/Trucks Toward New Fuels**
  - » **Hybrid/Electric Vehicles**
  - » **Alternative Fuel Vehicles & Bio-Based Fuels**
  - » **Other Alternatives**
- **Efficiency (All Sectors)**
- **Other GHGs**
- **Enablers**
  - » **CO_2 Capture and Storage**
  - » **Modernized Grid**
  - » **Energy Storage**
  - » **Strategic Research**

Supporting Policies

- **Financial Incentives**
- **Fuel Mandates**
- **Codes, Standards, Labeling**
- **Transparent System for Measuring Progress**

Establish U.S. Climate Change Technology Program

- **Strengthen Federal R&D Portfolio**
- **Prioritize Investments**

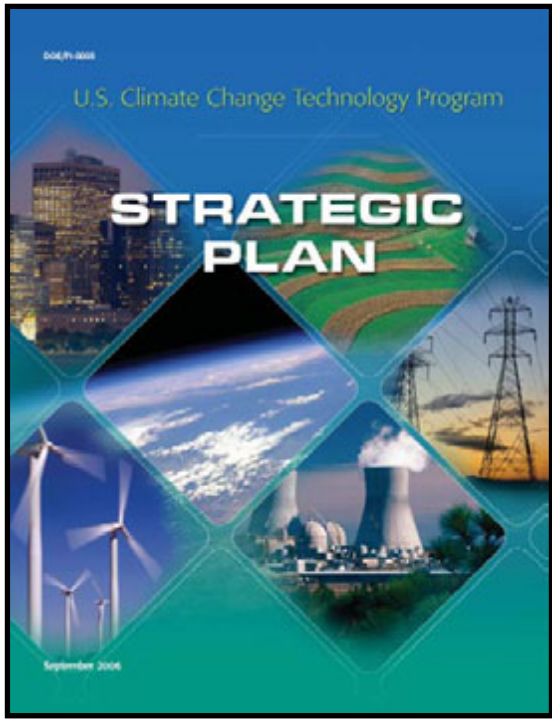
Technology: Seeking Better and More Cost-Effective Solutions

U.S. Climate Change Technology Program

- Authorized in EPAct 2005
- An Ambitious Program of RDD&D
- $4 Billion/Year

Climate Technology Goals:

1. Reduce Emissions From Energy End Use & Infrastructure
2. Reduce Emissions From Energy Supply
3. Capture & Sequester CO_2
4. Reduce Emissions From Non-CO_2 Gases
5. Improve Capabilities to Measure & Monitor GHG
6. Bolster Basic Science



www.climatetechnology.gov

Federal Agency Participation in CCTP

Agency	Selected Examples of Climate Change-Related Technology R&D Activities
DOC	Instrumentation, Standards, Ocean Sequestration, Decision Support Tools
DoD	Aircraft, Engines, Fuels, Trucks, Equipment, Power, Fuel Cells, Lasers, Energy Management, Basic Research
DOE	Energy Efficiency, Renewable Energy, Nuclear Fission and Fusion, Fossil Fuels and Power, Carbon Sequestration, Basic Energy Sciences, Hydrogen, Bio-Fuels, Electric Grid and Infrastructure
DOI	Land, Forest, and Prairie Management, Mining, Sequestration, Geothermal, Terrestrial Sequestration Technology Development
DOS*	International Science and Technology Cooperation, Oceans, Environment
DOT	Aviation, Highways, Rail, Freight, Maritime, Urban Mass Transit, Transportation Systems, Efficiency and Safety
EPA	Mitigation of CO2 and Non-CO2 GHG Emissions through Voluntary Partnership Programs, including Energy STAR, Climate Leaders, Green Power, Combined Heat and Power, State and Local Clean Energy, Methane and High-GWP Gases, and Transportation; GHG Emissions Inventory
HHS*	Environmental Sciences, Biotechnology, Genome Sequencing, Health Effects
NASA	Earth Observations, Measuring, Monitoring, Aviation Equipment, Operations and Infrastructure Efficiency
NSF	Geosciences, Oceans, Nanoscale Science and Engineering Computational Sciences
USAID*	International Assistance, Technology Deployment, Land Use, Human Impacts
USDA	Carbon Fluxes in Soils, Forests and Other Vegetation, Carbon Sequestration, Nutrient Management, Cropping Systems, Forest and Forest Products Management, Livestock, and Waste Management, Biomass Energy and Bio-based Products Development

* CCTP-related funding for the indicated agencies is not included in the totals for CCTP in the budget tables of Appendix A of the Strategic Plan. However, the agencies participate in CCTP R&D planning and coordination as members of CCTP's Working Groups.

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 • High-Performance Integrated 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 • "Smart" Buildings • Transformational Technologies for Energy-Intensive Industries • Energy Storage for Load Leveling	• Widespread Use of Engineered Urban Designs & Regional Planning • Energy Managed 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 Wind Speed Turbines • Advanced Biorefineries • Community-Scale Solar • Gen IV Nuclear Plants • Fusion Pilot Plant Demonstration	• Zero-Emission Fossil Energy • H_2 & Electric Economy • Widespread Renewable Energy • Bio-Inspired Energy & Fuels • Widespread Nuclear Power • Fusion Power Plants
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 Landfill Gas Utilization • Soil Microbial Processes • Substitutes for SF_6 • Catalysts That Reduce N_2O to Elemental Nitrogen in Diesel Engines	• Integrated Waste Management 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)

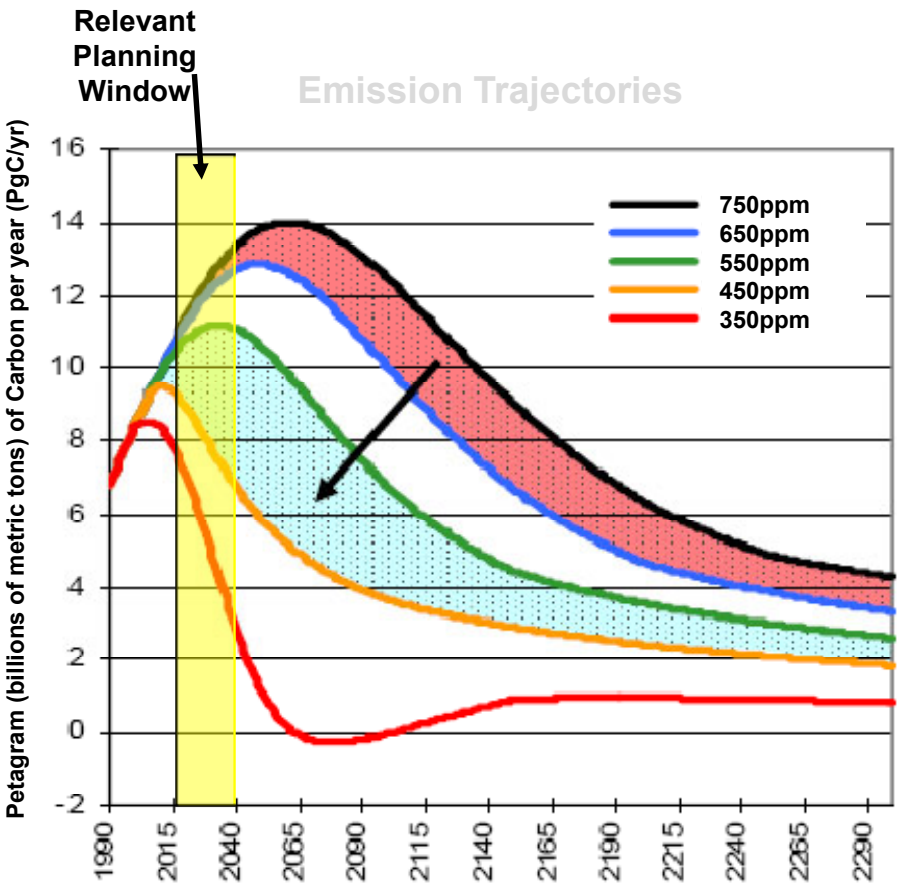
Advanced Technology Scenario Analysis

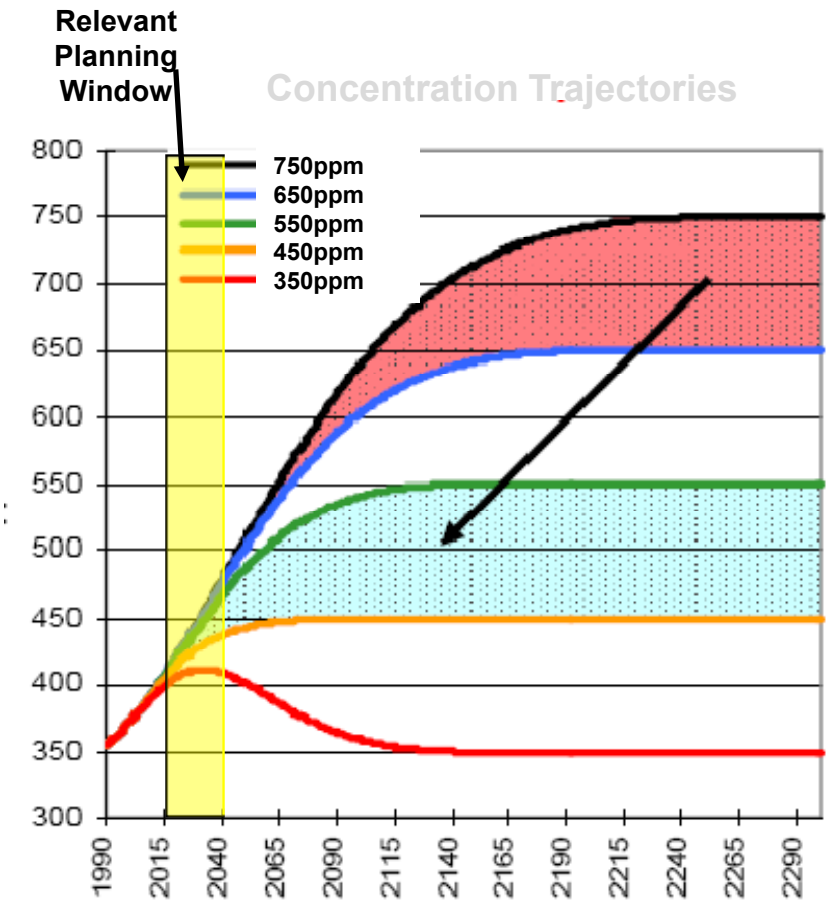
Planning & Analysis Under Conditions of Uncertainty

- Global Perspective
- 100-Year Planning Horizon
- Uncertainty Across GHG Stabilization Goals
- Technology Scenarios
- Technology Competitions
- Economic Benefits

www.globalchange.umd.edu/data/publications/CCTP_Final_Report_041007.pdf

Long-Term Goals Require Near-Term Actions



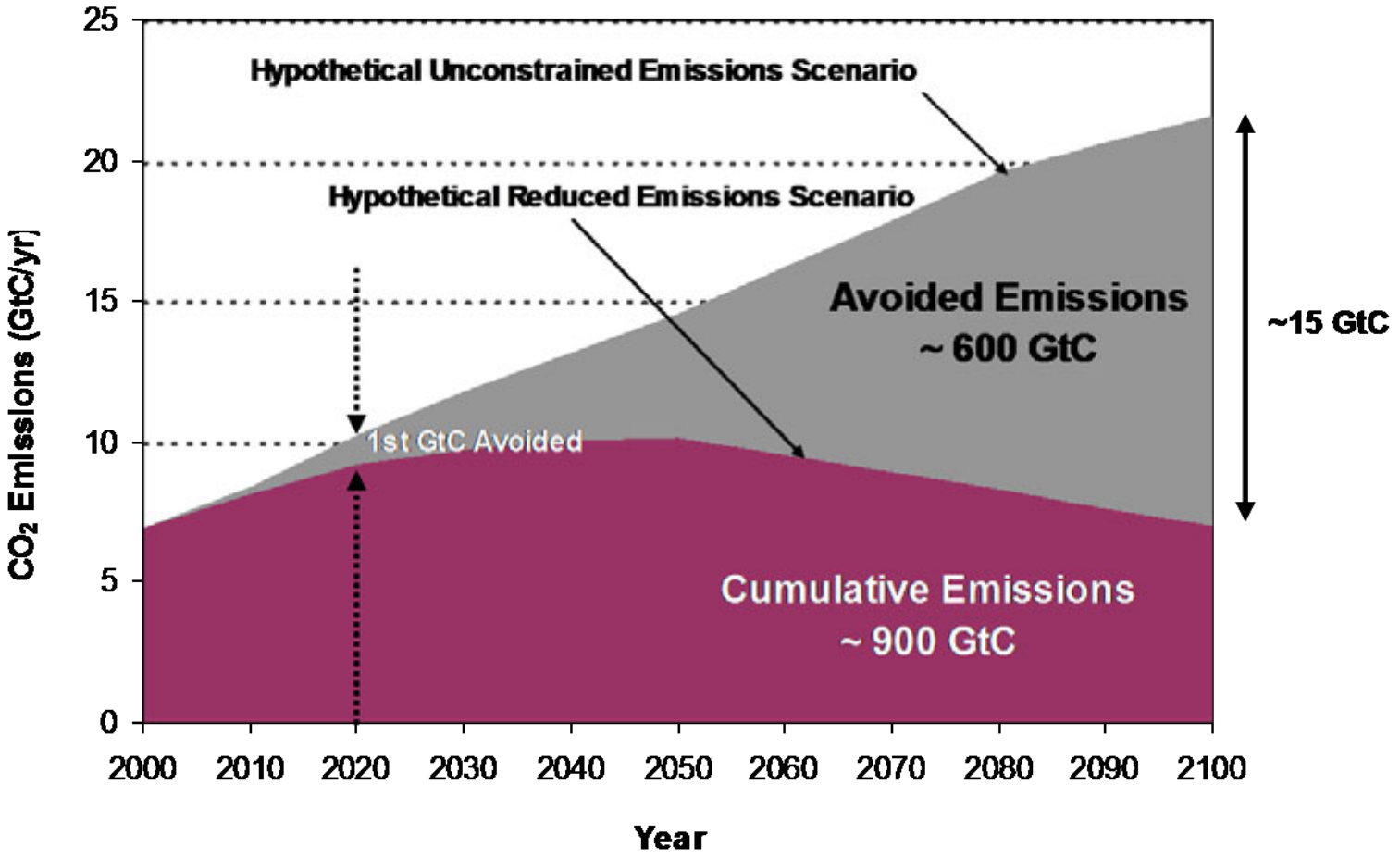


Emission and concentration trajectories based on current funding profile for technology investments

Potential carbon reductions based on proposed technology investments

Action period to influence longer-term outcomes

Mid-Range Example of A Reduced GHG Emissions Future



GtC = Giga-Tonnes Carbon

Giga-Tonne = Billion (10^9) Metric-Tonnes (1000 Kilograms)

How Big is a Gigaton? Using Today's Technology, These Actions Can Cut Emissions by 1 GtC/Year

Today's Technology	Actions that Provide 1 Gigaton / Year of Mitigation
Coal-Fired Power Plants	Build 1,000 "zero-emission" 500-MW coal-fired power plants (in lieu of coal-fired plants without CO_2 capture and storage)
Geologic Sequestration	Install 3,700 sequestration sites like Norway's Sliepner project (0.27 MtC/year)
Nuclear	Build 500 new nuclear power plants, each 1 GW in size (in lieu of new coal-fired power plants without CO_2 capture and storage)
Electricity from Landfill Gas Projects	Install 7,874 "typical" landfill gas electricity projects (typical size being 3 MW projects at non-regulated landfills) that collect landfill methane emissions and use them as fuel for electric generation.
Efficiency	Deploy 1 billion new cars at 40 miles per gallon (mpg) instead of new cars at 20 mpg
Wind Energy	Install 650,000 wind turbines (1.5 MW each, operating at 0.45 capacity factor) in lieu of coal-fired power plants without CO_2 capture and storage.
Solar Photovoltaics	Install 6 million acres of solar photovoltaics to supplant coal-fired power plants without CO_2 capture and storage (assuming 10% cell DC efficiency, 1700 kWhr/m2 solar radiance, and 90% DC-AC conversion efficiency).
Biomass fuels from plantations	Convert a barren area about 15 times the size of Iowa's farmland (about 33 million acres) to biomass crop production
CO_2 Storage in New Forest.	Convert a barren area about 40 times the size of Iowa's farmland to new forest

Giga-Tonne = Billion (10^9) Metric-Tonnes (1000 Kilograms)

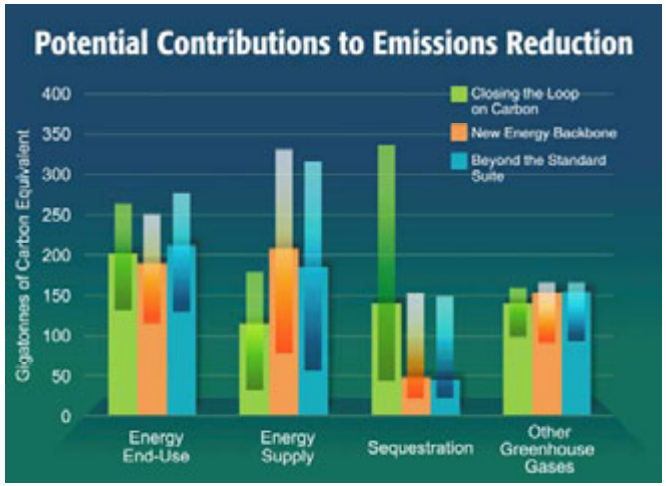
Scenario and Results

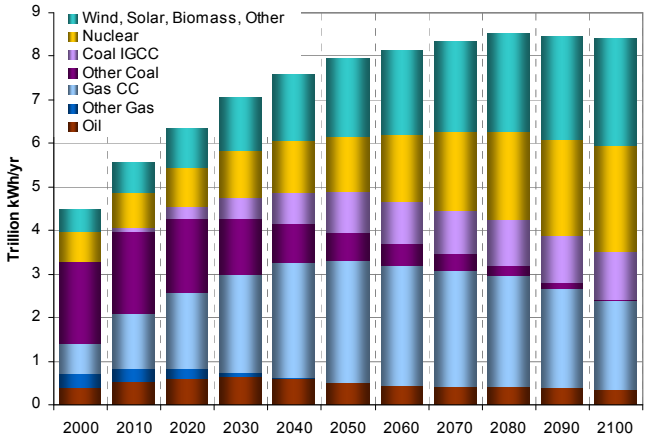
Advanced Technology Scenarios

#1: Closing the Loop on Carbon
- Advanced Coal Systems
- Carbon Capture and Storage
- Hydrogen Technologies

#2: New Energy Backbone
- Nuclear Power
- Wind Power
- Solar Power

#3: Beyond the Standard Suite
- Fusion Energy
- Novel Energy Technologies
- Bio-X
- Large Scale Solar





United States Electricity Consumption:
Closing the Loop on Carbon, 550 ppmv

Common Characteristics Across Scenarios

Additional Gains in Efficiency Beyond Ref. Case
Additional Technologies for Managing GHGs
Terrestrial Carbon Sequestration Increases
Full Potential of Conventional Oil & Gas Realized
Hydrogen Production Technology Advances

GHG Emissions

Unconstrained (Ref. Case)
Four Levels of Constraints

Quantities – Potential 100-Year Reductions

CCTP Strategic Goal	Very High Constraint	High Constraint	Medium Constraint	Low Constraint
Goal #1: Reduce Emissions from Energy End Use and Infrastructure	250 - 270	190 - 210	150 - 170	110 - 140
Goal #2: Reduce Emissions from Energy Supply	180 - 330	110 - 210	80 - 140	30 - 80
Goal #3: Capture and Sequester Carbon Dioxide	150 - 330	50 - 140	30 - 70	20 - 40
Goal #4: Reduce Emissions of Non-CO_2 GHGs	160 - 170	140 - 150	120 - 130	90 - 100

Estimated cumulative GHG emissions mitigation (GtC) from accelerated adoption of advanced technologies over the 21st century, by strategic goal, across a range of hypothesized GHG emissions constraints.

Source: Clarke, L., M. Wise, M. Placet, C. Izaurralde, J. Lurz, S. Kim, S. Smith, and A. Thomson. 2006. Climate Change Mitigation: An Analysis of Advanced Technology Scenarios. Richland, WA: Pacific Northwest National Laboratory.

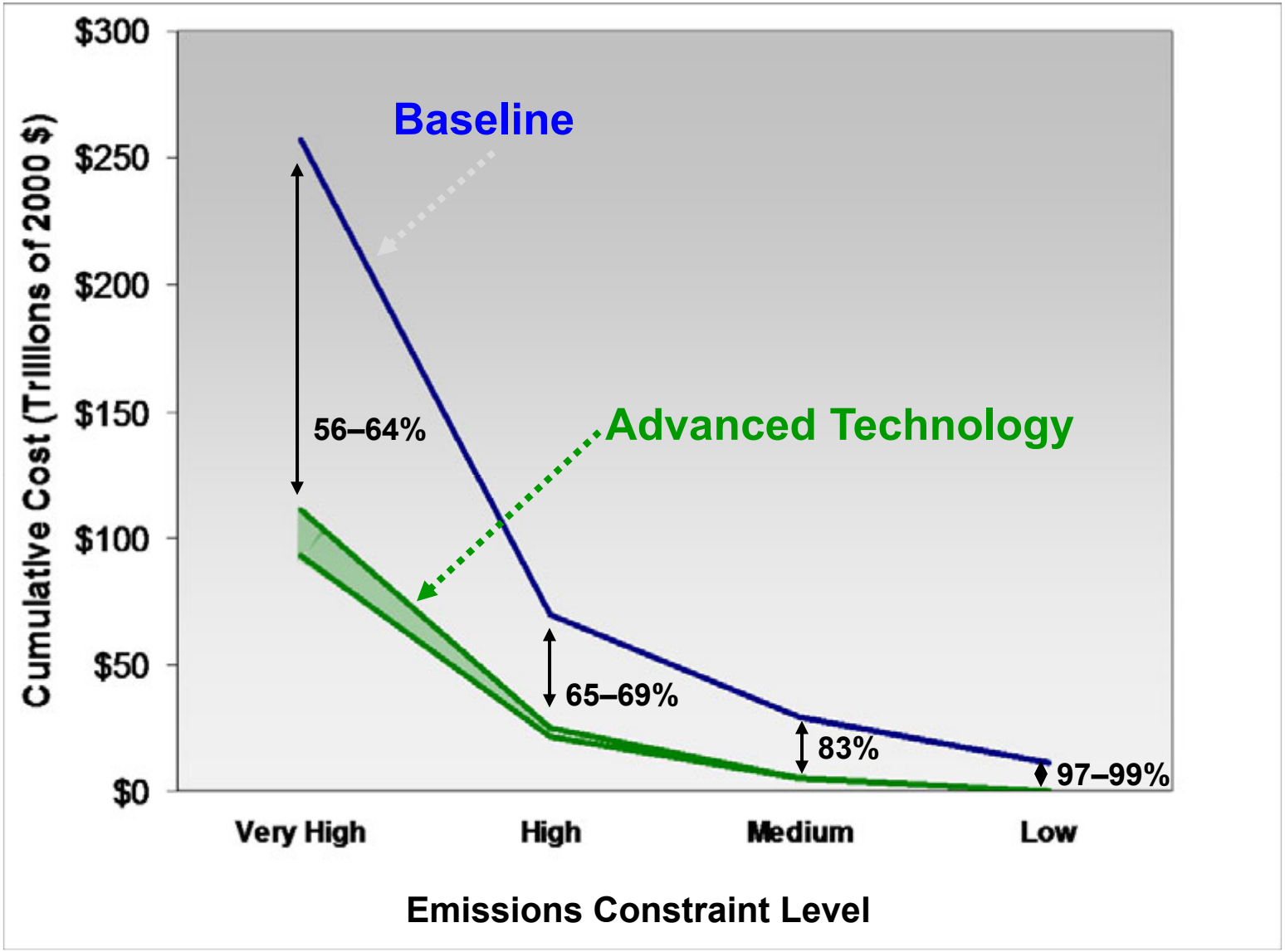
Timing

CCTP Strategic Goal	Very High Constraint	High Constraint	Medium Constraint	Low Constraint
Goal #1: Reduce Emissions from Energy End Use and Infrastructure	2010 - 2020	2030 - 2040	2030 - 2050	2040 - 2060
Goal #2: Reduce Emissions from Energy Supply	2020 - 2040	2040 - 2060	2050 - 2070	2060 – 2100
Goal #3: Capture and Sequester Carbon Dioxide	2020 - 2050	2040 or Later	2060 or Later	Beyond 2100
Goal #4: Reduce Emissions of Non-CO_2 GHGs	2020 - 2030	2050 - 2060	2050 - 2060	2070 - 2080

Estimated timing of advanced technology market penetrations, as indicated by the first GtC-eq./year of incremental emissions mitigation, by strategic goal, across a range of hypothesized GHG emissions constraints.

Source:: Clarke, L., M. Wise, M. Placet, C. Izaurralde, J. Lurz, S. Kim, S. Smith, and A. Thomson. 2006. Climate Change Mitigation: An Analysis of Advanced Technology Scenarios. Richland, WA: Pacific Northwest National Laboratory.

Expected Global Benefits of Advanced Technology Development



Technology R&D Portfolio Analysis

Role for CCTP

Strengthen the Federal R&D Portfolio

Provide Strategic Direction to R&D Agencies

Monitor Progress Toward Goals

Assess Portfolio Strengths and Weaknesses

Identify Gaps and Opportunities

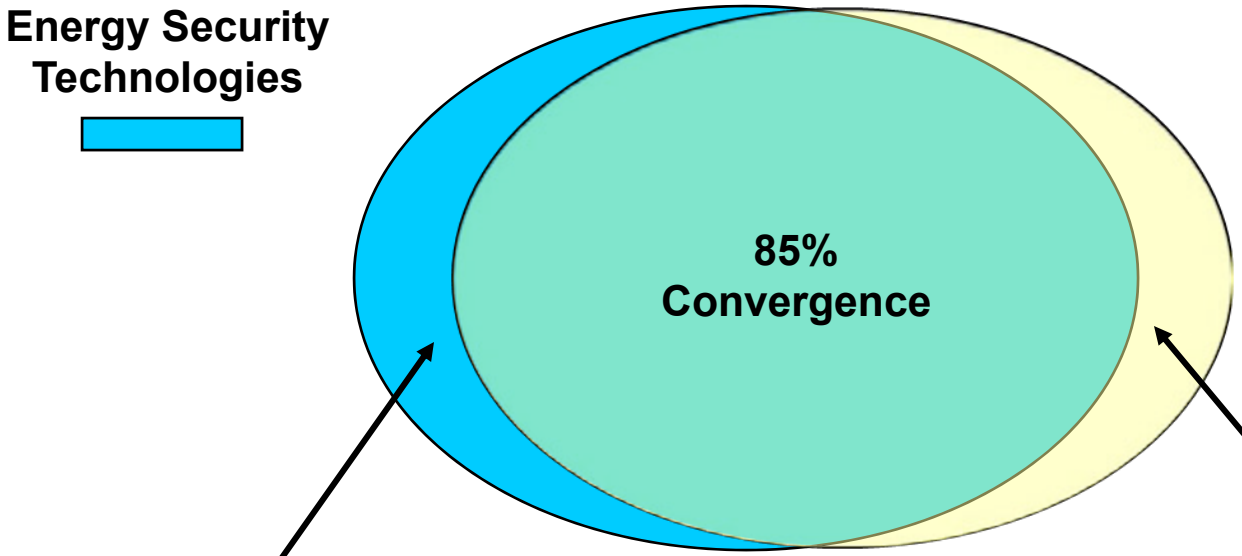
Prioritize Investments

- Portfolio Planning Principles
- Investment Criteria

Make Recommendations

Foster Collaborations with Non-Federal Entities

Technology Nexus Between Energy Security and Climate Change Strategies



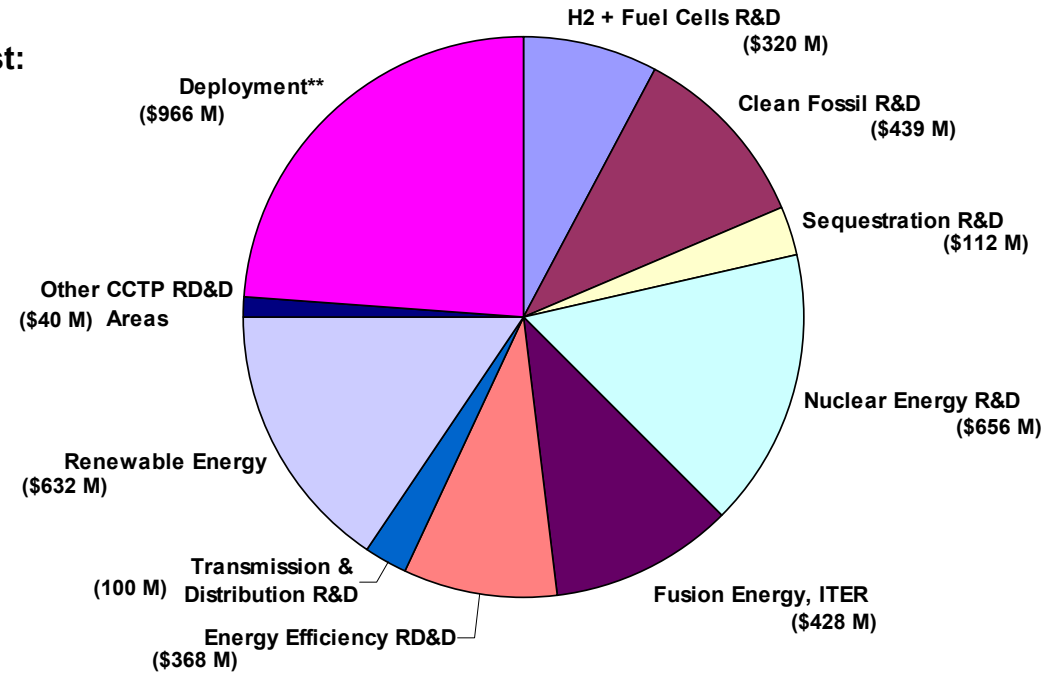
Exceptions:
- Coal to Liquids
- Oil Shale
- Methane Hydrates
- Petroleum Reserves

Exceptions:
- Non-CO2 Gases
- Forestry/Land Use
- Agriculture
- Terrestrial Sequestration

FY 2008 Budget Request -- CCTP Portfolio

CCTP FY08 Budget Request*
Portfolio of RD&D and Deployment

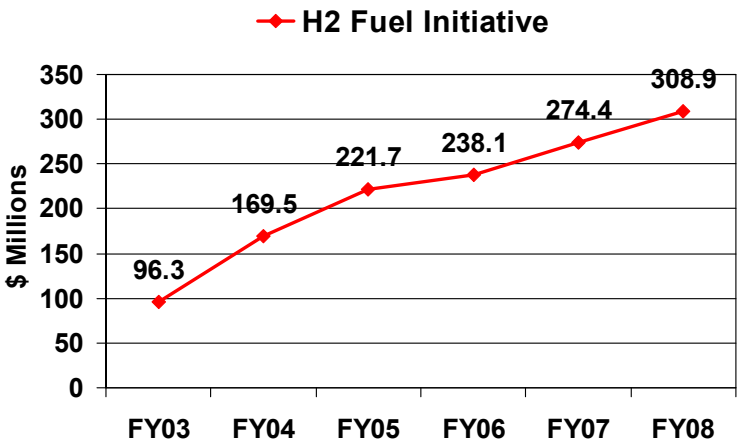
Total Multi-Agency FY08 Budget Request: $ 4,070 Million

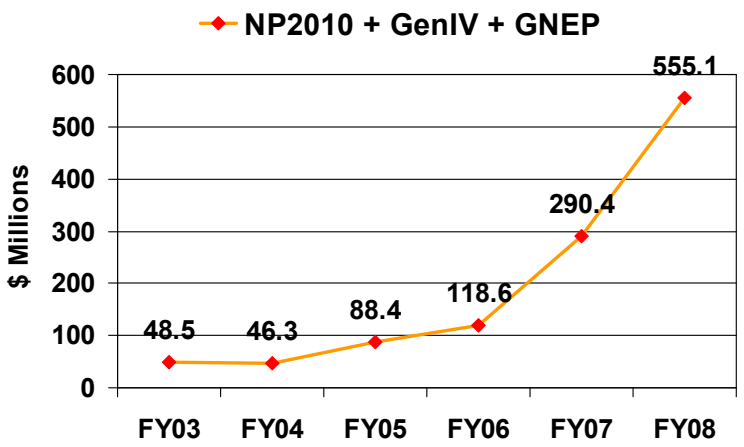


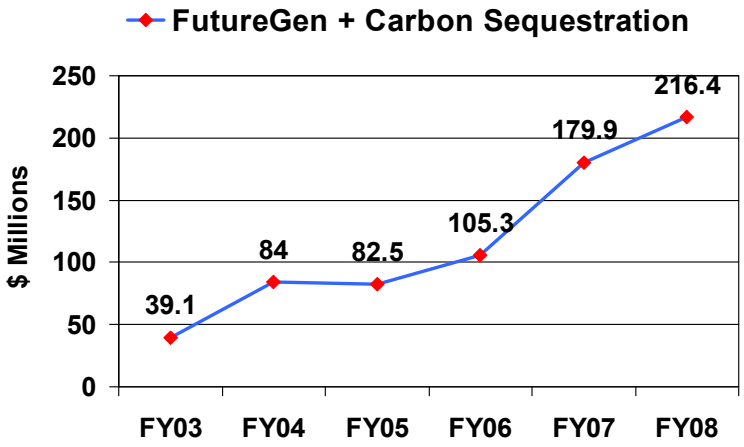
* All CCTP Federal Agencies FY08 Budget Request (inc: USAID & STATE)

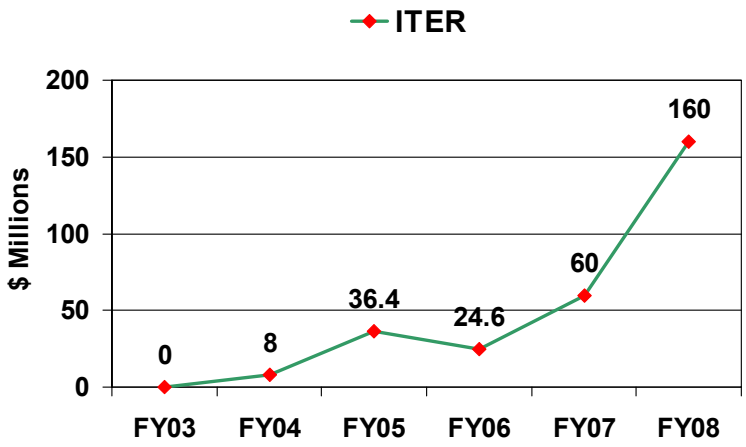
** Deployment is 55% Energy Efficiency

FY 2008 Budget Request – Key Initiatives









Potential Role of Hydrogen*

Hydrogen is a highly versatile energy carrier

- Capable of transforming transportation (and potentially other energy services)
- Compatible with many primary energy sources
- Can be generated at various scales

Versatility opens up possibilities for long-term dynamic optimization:

- CO_2 emissions, technology development lead times, economics, and other factors

May ultimately serve as a means of linking energy sources to energy uses in ways that are more flexible, secure, reliable, and responsive to consumer demands than today

May also help integrate the transportation and electricity markets

Production can be a value-added complement to other advanced climate change technologies, such as fossil fuels or biomass with CO_2 capture and storage

May be a key and enabling component for full deployment of carbonless electricity technologies (advanced fission, fusion, and/or intermittent renewables)

* See Strategic Plan, U.S. Climate Change Technology Program, September 2006

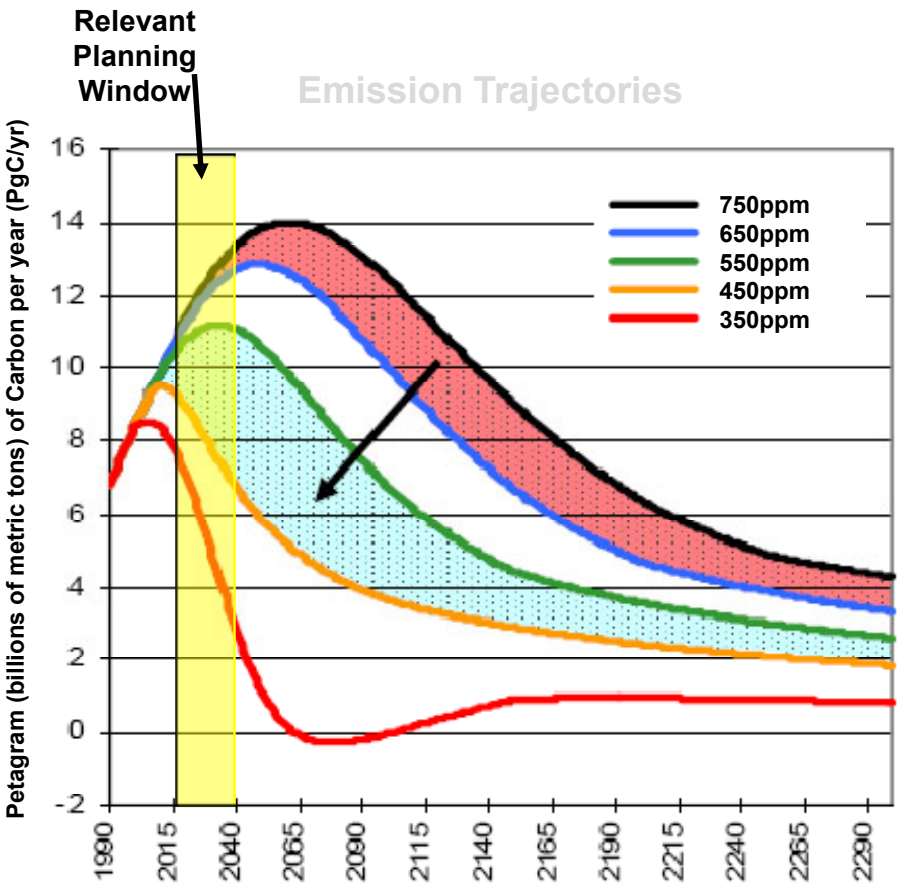
Hydrogen Fuel Initiative
Budget by Participant Organization

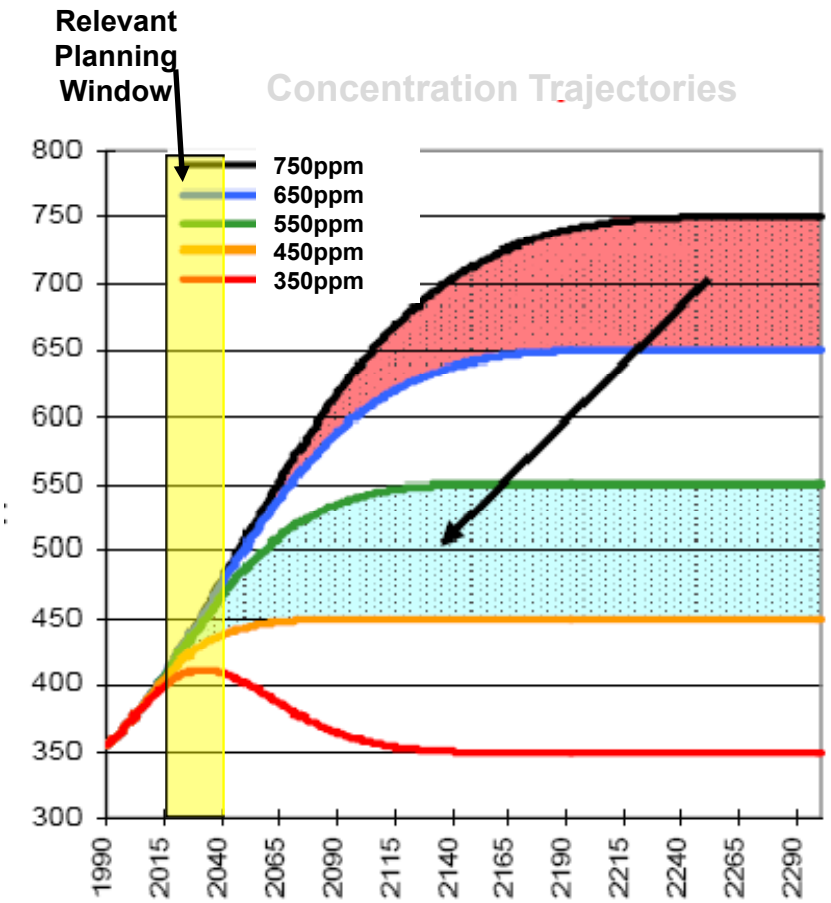
Activity	Funding ($ in thousands)			
	FY2005 Approp	FY2006 Approp	FY2007 Actual	FY2008 Request
Hydrogen Fuel Initiative				
EERE Hydrogen (HFCIT)	166,772	153,451	193,551	213,000
Fossil Energy (FE)	16,518	21,036	23,611	12,450
Nuclear Energy (NE)	8,682	24,057	18,665	22,600
Science (SC)	29,183	32,500	36,500	59,500
DOE Hydrogen TOTAL	**221,155**	**231,044**	**272,327**	**307,550**
Department of Transportation	549	1,411	1,420	1,425
Hydrogen Fuel Initiative TOTAL	**221,704**	**232,455**	**273,747**	**308,975**

EERE Hydrogen Budget

Activity	Funding ($ in thousands)			
	FY 2005 Approp	FY 2006 Approp	FY 2007 Actual	FY 2008 Request
Hydrogen Production & Delivery	13,303	8,391	34,594	40,000
Hydrogen Storage R&D	22,418	26,040	34,620	43,900
Fuel Cell Stack Component R&D	31,702	30,710	38,082	44,000
Technology Validation	26,098	33,301	39,566	30,000
Transportation Fuel Cell Systems	7,300	1,050	7,518	8,000
Distributed Energy Fuel Cell Sys.	6,753	939	7,419	7,700
Fuel Processor R&D	9,469	637	4,056	3,000
Safety, Codes & Standards	5,801	4,595	13,848	16,000
Education	0	481	1,978	3,900
Systems Analysis	3,157	4,787	9,892	11,500
Manufacturing R&D	0	0	1,978	5,000
Technical/Program Mgt. Support	535	0	0	0
Congressionally Directed Activities	40,236	42,520	0	0
TOTAL	**166,772**	**153,451**	**193,551**	**213,000**

Long-Term Goals Require Near-Term Actions





Emission and concentration trajectories based on current funding profile for technology investments

Potential carbon reductions based on proposed technology investments

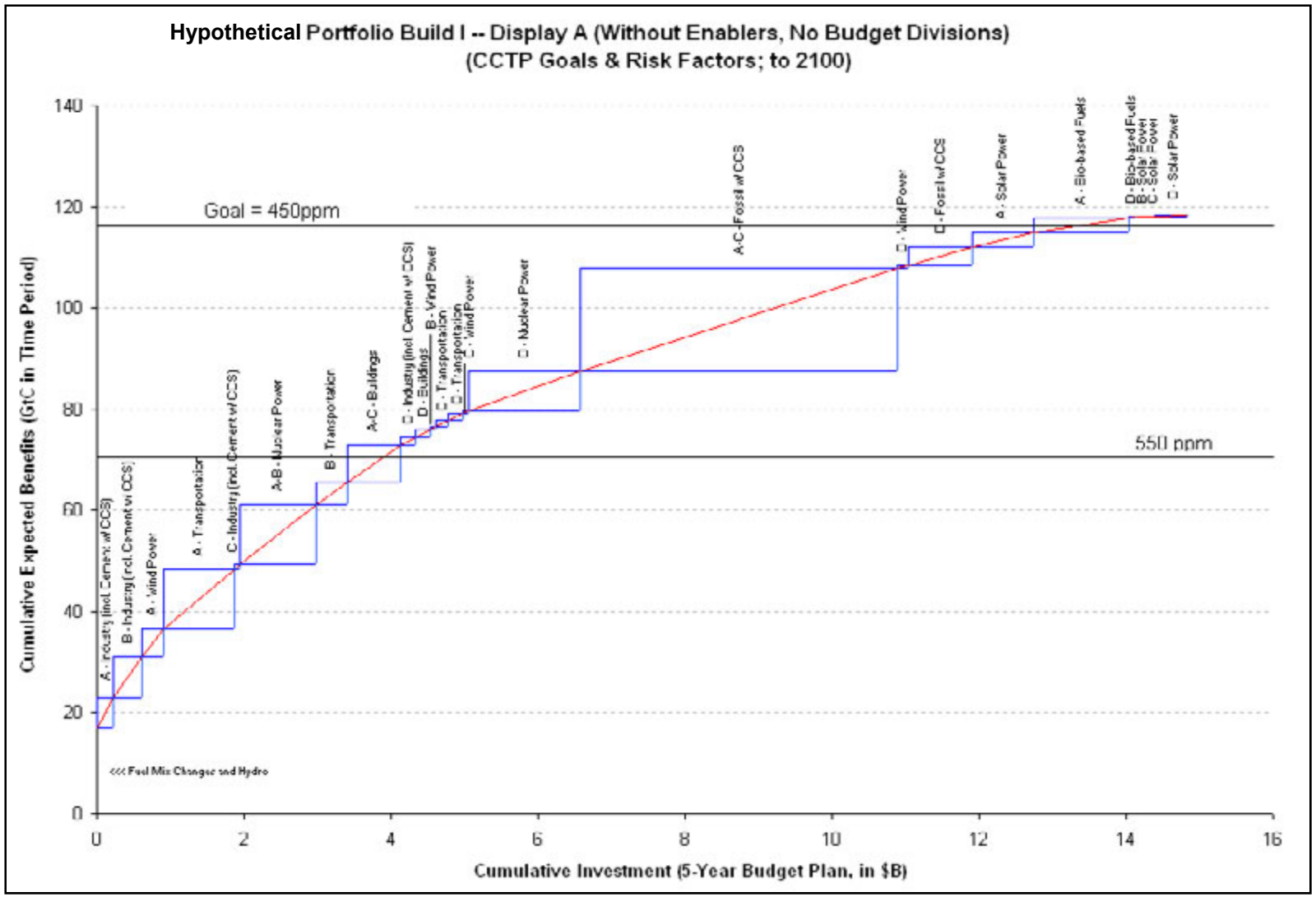
Action period to influence longer-term outcomes

CCTP Portfolio Assessment

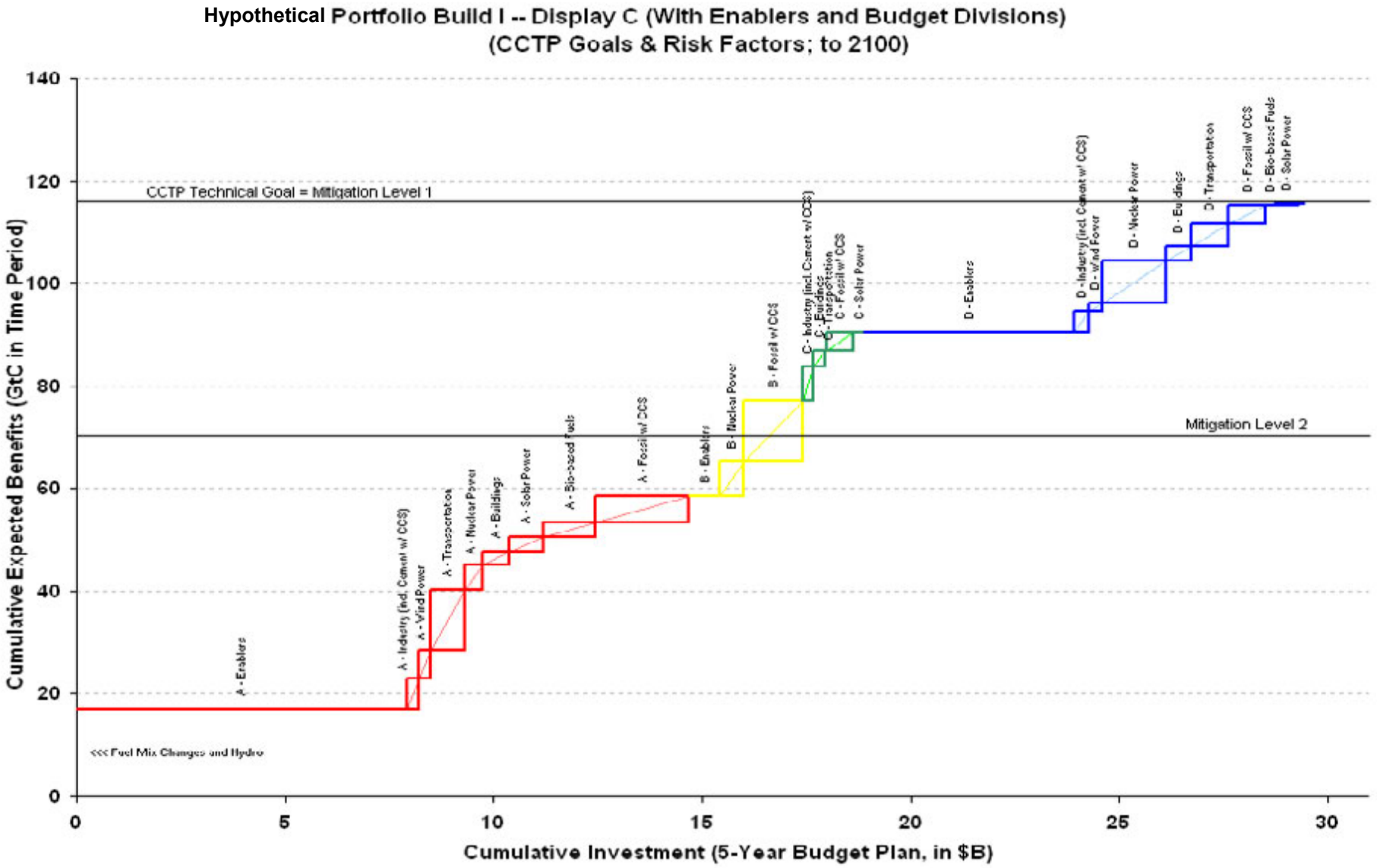
CCTP Strategic Goal		Key Element of Strategy	Corresponding Technologies in Portfolio Analysis	Lead	Most Challenging Technical Scenario	Units	Scenarios Years & Quantities -- U.S. Only					Likelihood of CCTP Goal Attainment*				
							2020	2030	2040	2050	2100	Very Unlikely	Unlikely	Maybe	Likely	Very Likely
1 Reducing Emissions from Energy End-Use and Infrastructure	1.1	Transportation	Primary Energy Reduction	EE	BSS 450	GtC/yr	0.10	0.14	0.19	0.23	0.34			✓	✓	
	1.2	Buildings	Primary Energy Reduction	EE	BSS 450	GtC/yr	0.04	0.08	0.11	0.14	0.15			✓		
	1.3	Industry	Primary Energy Reduction	EE	BSS 450	GtC/yr	0.12	0.17	0.21	0.24	0.18		✓			
	1.4	Electric Grid and Infrastructure	Enabling Technology, U.S. Grid Demand	OE	NEB 450	Trillion kWh/yr	6.67	7.35	7.92	8.38	9.49		✓		✓	
2 Reducing Emissions from Energy Supply	2.1	Low Emission, Fossil-Based Fuels and Power	Electricity: Coal w/CCS	FE	CLC 450	GtC/yr	0.02	0.05	0.11	0.19	0.33		✓		✓	
			Electricity: Natural Gas w/CCS	FE	CLC 450	GtC/yr	0.02	0.04	0.08	0.15	0.26	✓				
	2.2	Hydrogen	Hydrogen Production	EE	CLC 450	Quads	2.40	3.10	4.00	5.10	7.40			✓		
	2.3	Renewable Energy and Fuels	Electricity: Solar Power	EE	NEB 450	GtC/yr	0.00	0.00	0.02	0.04	0.06		✓			
			Electricity: Wind Power	EE	NEB 450	GtC/yr	0.00	0.02	0.06	0.11	0.13		✓			
			Bio-Based Fuels	EE	BSS 450	GtC/yr	0.00	0.00	0.02	0.05	0.06				✓	
	2.4	Nuclear Fission	Electricity: Gen III Reactors	NE	NEB 450	GtC/yr	0.01	0.05	0.13	0.24	0.37			✓	✓	
			Electricity: Gen IV Reactors	NE	NEB 450	GtC/yr	0.00	0.00	0.02	0.06	0.15		✓			
			Electricity: International Tech. --GNEP	NE	NEB 450/W	Trillion kWh/yr	0.01	0.01	0.02	21.94	39.06		✓			
	2.5	Fusion Energy	Electricity: Fusion Energy, Others	SC	BSS 450	GtC/yr	0.00	0.00	0.01	0.04	0.35	✓				
3 Capturing and Sequestering Carbon Dioxide	3.1	Carbon Capture	(Embedded in 2.1)	FE	CLC 450	GtC/yr	0.01	0.01	0.03	21.99	39.41		✓		✓	
	3.2	Geological Storage	Carbon Storage	FE	CLC 450	GtC/yr	0.04	0.09	0.20	0.35	0.61		✓		✓	
	3.3	Terrestrial Sequestration	TBD	USDA	TBD	GtC/yr	TBD									
	3.4	Ocean Sequestration	Not Applicable This Round	DOE	N/A	N/A	TBD									
4 Reducing Emissions of Non-CO_2 Greenhouse Gasses	4.1	Methane Emissions from Energy and Waste	CH_4 in CO_2-Equivalence	DOE/EPA	CLC 450	GtC-Eq./yr	TBD						✓			
	4.2	Methane and Nitrous Oxide Emissions from Agriculture	TBD--CH_4 (Part)	USDA	CLC 450	GtC-Eq./yr	TBD						✓			
			TBD--N_2O (Part)	USDA	CLC 450	GtC-Eq./yr	TBD						✓			
	4.3	Emissions of High Global-Warming Potential Gases	Short-Lived F-Gases in CO_2-Equivalence	EPA	CLC 450	GtC-Eq./yr	TBD								✓	
			Long-Lived F-Gases in CO_2-Equivalence	EPA	CLC 450	GtC-Eq./yr	TBD								✓	
	4.4	Nitrous Oxide Emissions from Combustion and Industrial Sources	N_2O in CO_2-Equivalence	EPA	CLC 450	GtC-Eq./yr	TBD						✓			
	4.5	Emissions of Tropospheric Ozone Precursors and Black Carbon	TBD	EPA	TBD	GtC-Eq./yr	TBD									
5 Enhancing Capabilities to Measure and Monitor Greenhouse Gasses	5.2	MM -- Energy Production and Efficiency	N/A	DOE	N/A	N/A	Refer to Strategic Plan, Chapter 8							✓		
	5.3	MM -- CO_2 Capture and Sequestration	N/A	DOE	N/A	N/A	Refer to Strategic Plan, Chapter 8							✓		
	5.4	MM -- Other Greenhouse Gases	N/A	EPA	N/A	N/A	Refer to Strategic Plan, Chapter 8							✓		
	5.5	MM -- Integrated Systems Architecture	N/A	SC	N/A	N/A	Refer to Strategic Plan, Chapter 8						✓			
6 Bolster Basic Science Contributions to Technology Development	6.1	Strategic Research	N/A	SC	N/A	N/A	Refer to Strategic Plan, Chapter 9								✓	
	6.2	Fundamental Science	N/A	SC	N/A	N/A	Refer to Strategic Plan, Chapter 9									
	6.3	Exploratory Research	N/A	SC	N/A	N/A	Refer to Strategic Plan, Chapter 9					✓				

*** Very Likely (90-100%); Likely (60-90%); Maybe (40-60%); Unlikely (10-40%); Very Unlikely (0-10%)**

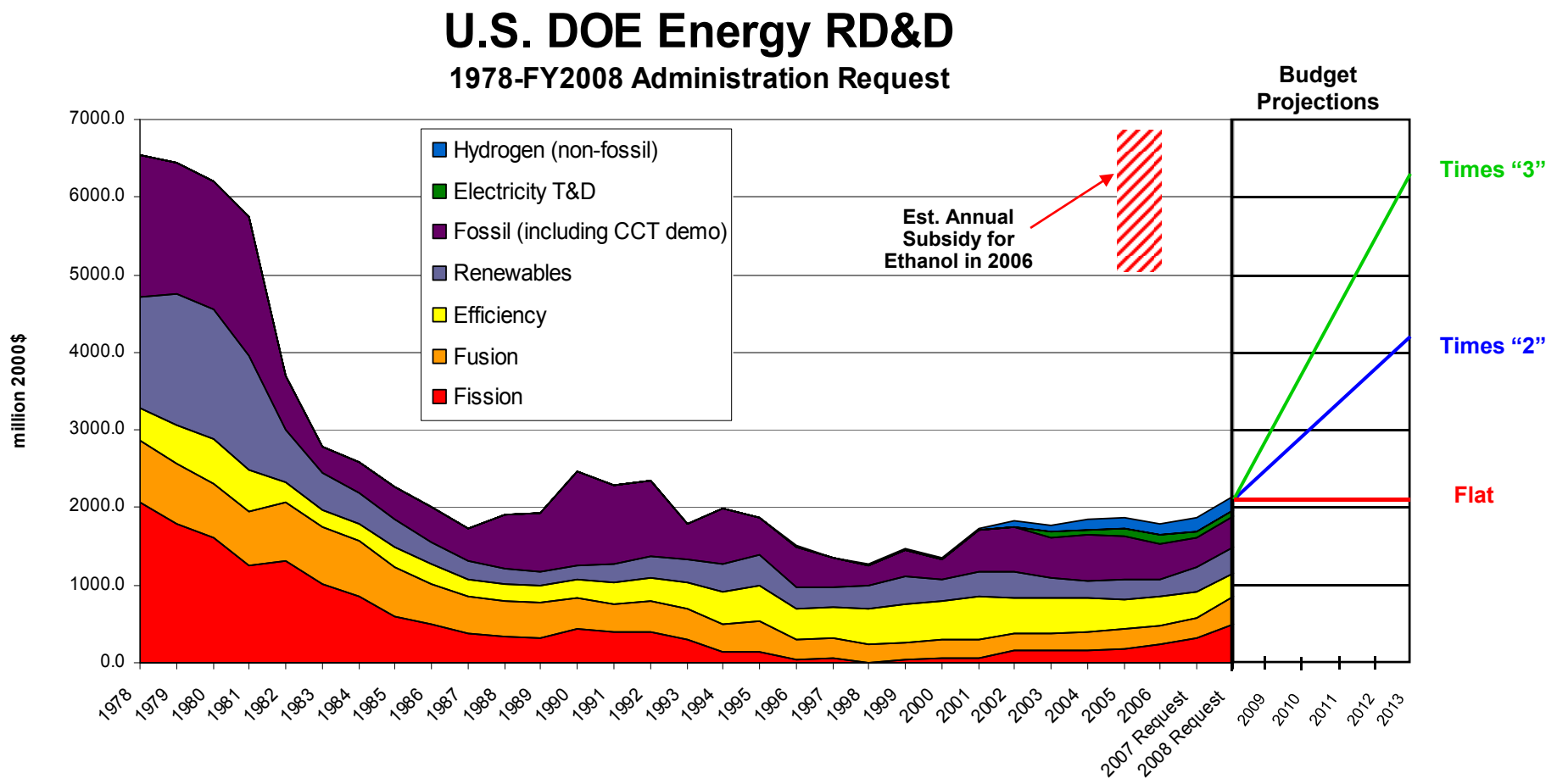
Hypothetical Portfolio Build – Display A



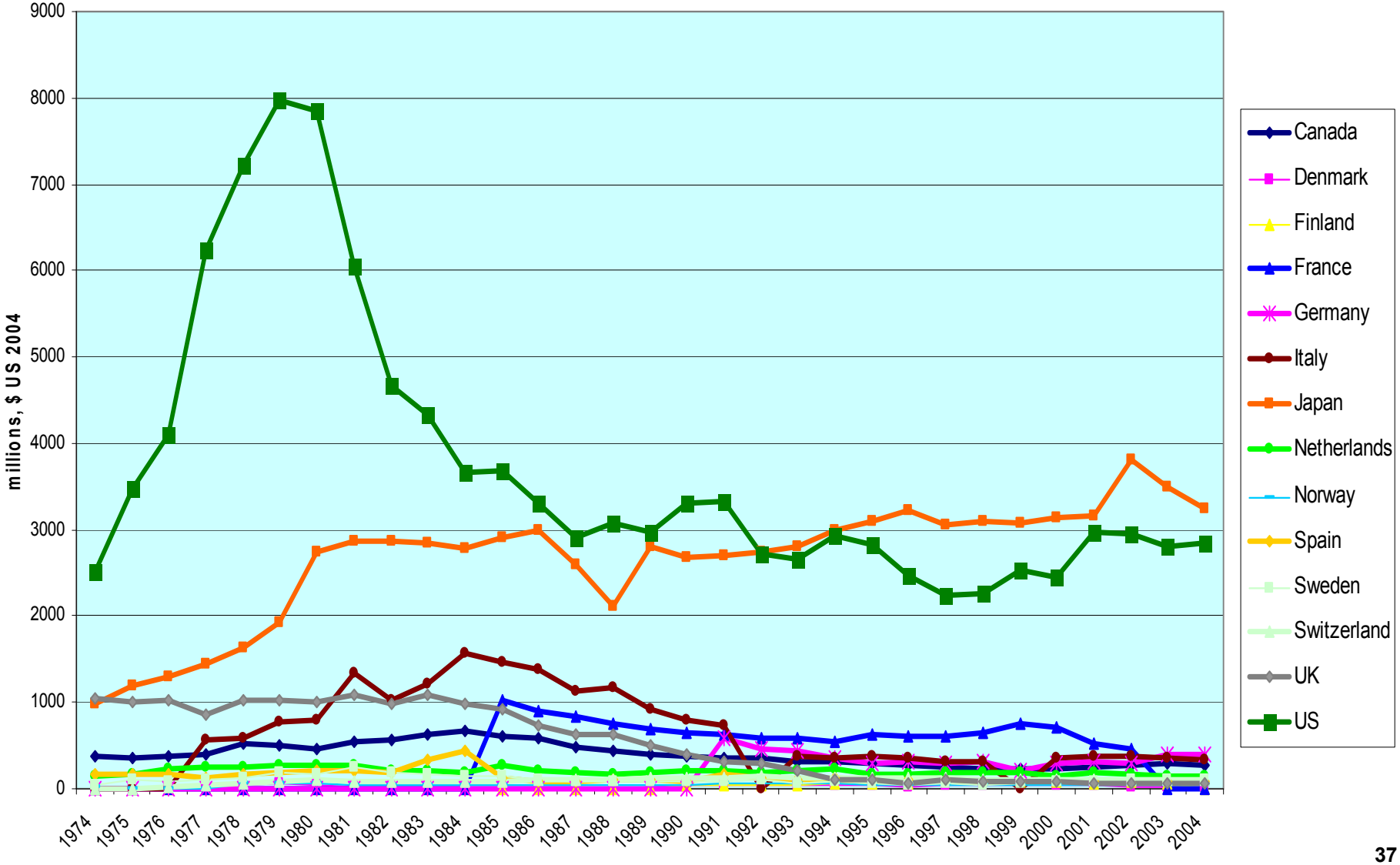
Hypothetical Portfolio Build – Display C



Historical Perspective



History of Int'l Energy R&D



Supporting Policy and Measures

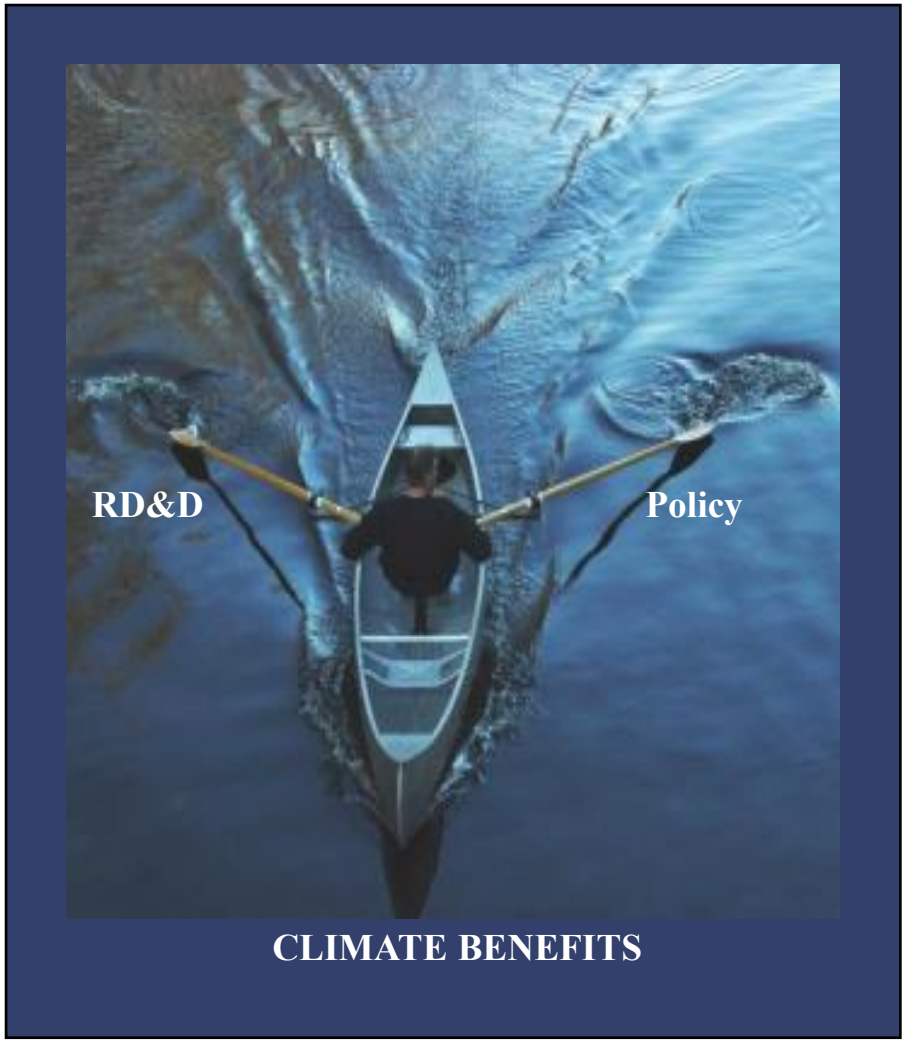
Supporting Policy and Measures

Technology Strategy

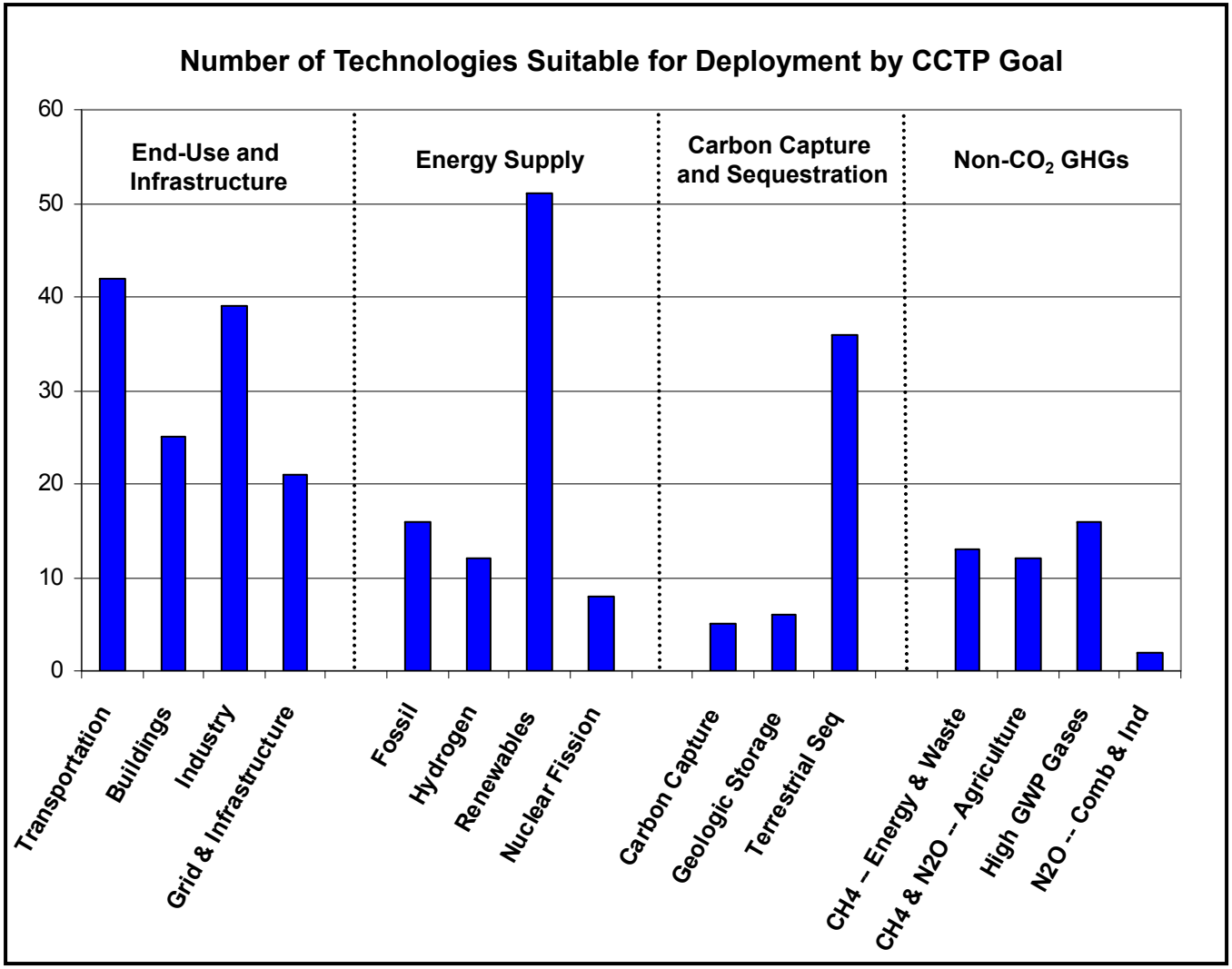
- Technology RD&D
- Supporting Policy and Measures

Need Both for:

- Timely Deployment
- Realization of Expected Benefits



Technology Taxonomy & Inventory



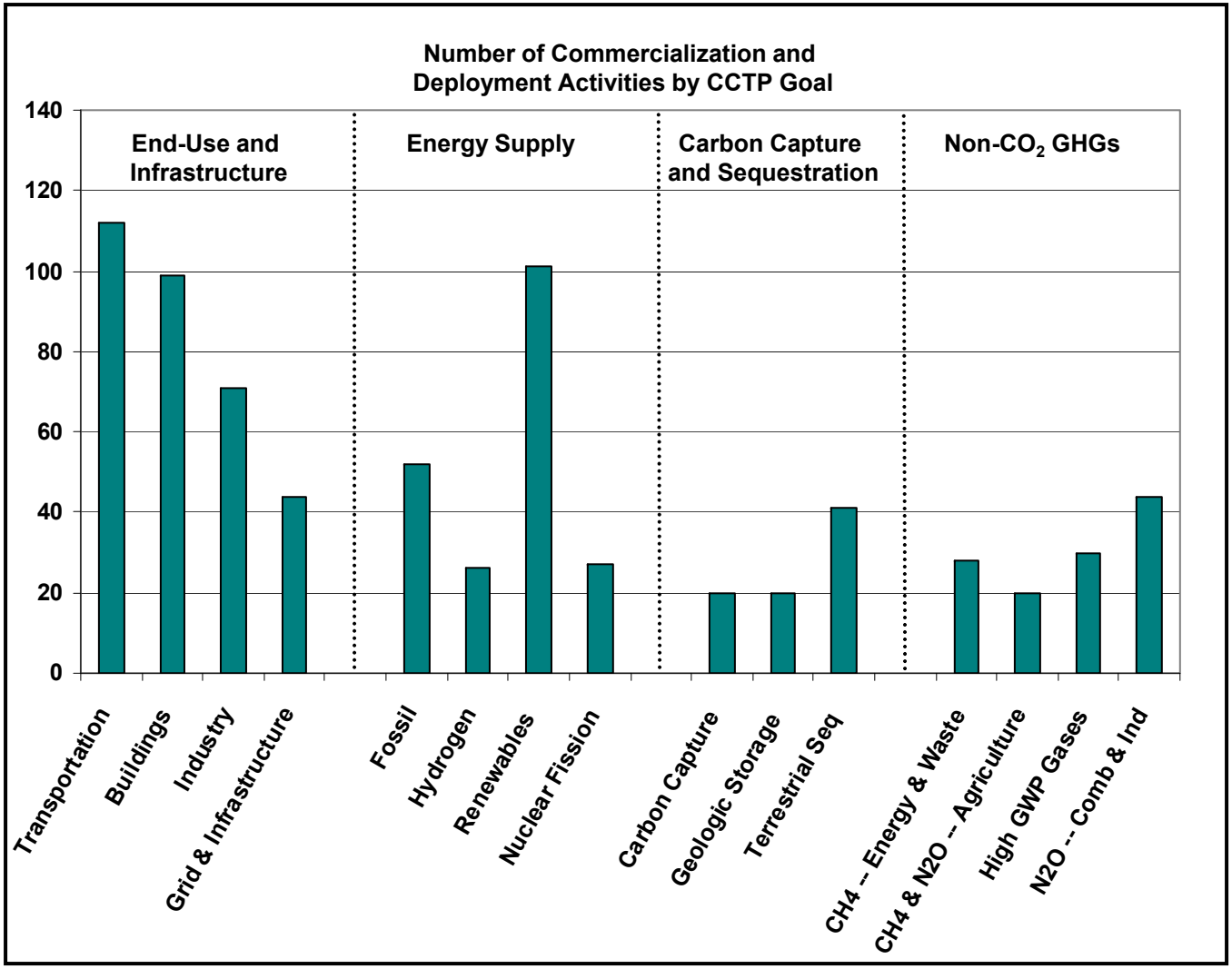
Barriers Typology

Cost Effectiveness	Fiscal Barriers	Regulatory Barriers	Statutory Barriers	Intellectual Property Barriers	Other Barriers
High Costs	Unfavorable Fiscal	Unfavorable Regulations	Unfavorable Statutes	IP Transaction Costs	Incomplete and Imperfect Information
Technical Risks	Fiscal Uncertainty	Regulatory Uncertainty	Statutory Uncertainty	Anti-competitive Patent Practices	Infrastructure limitations
Market Risks	Unfavorable tariffs			Weak International Patent Protection	Industry Structure
External Benefits and Costs				University, Industry, Government Perceptions	Misplaced Incentives
Lack of Specialized Knowledge					Policy Uncertainty

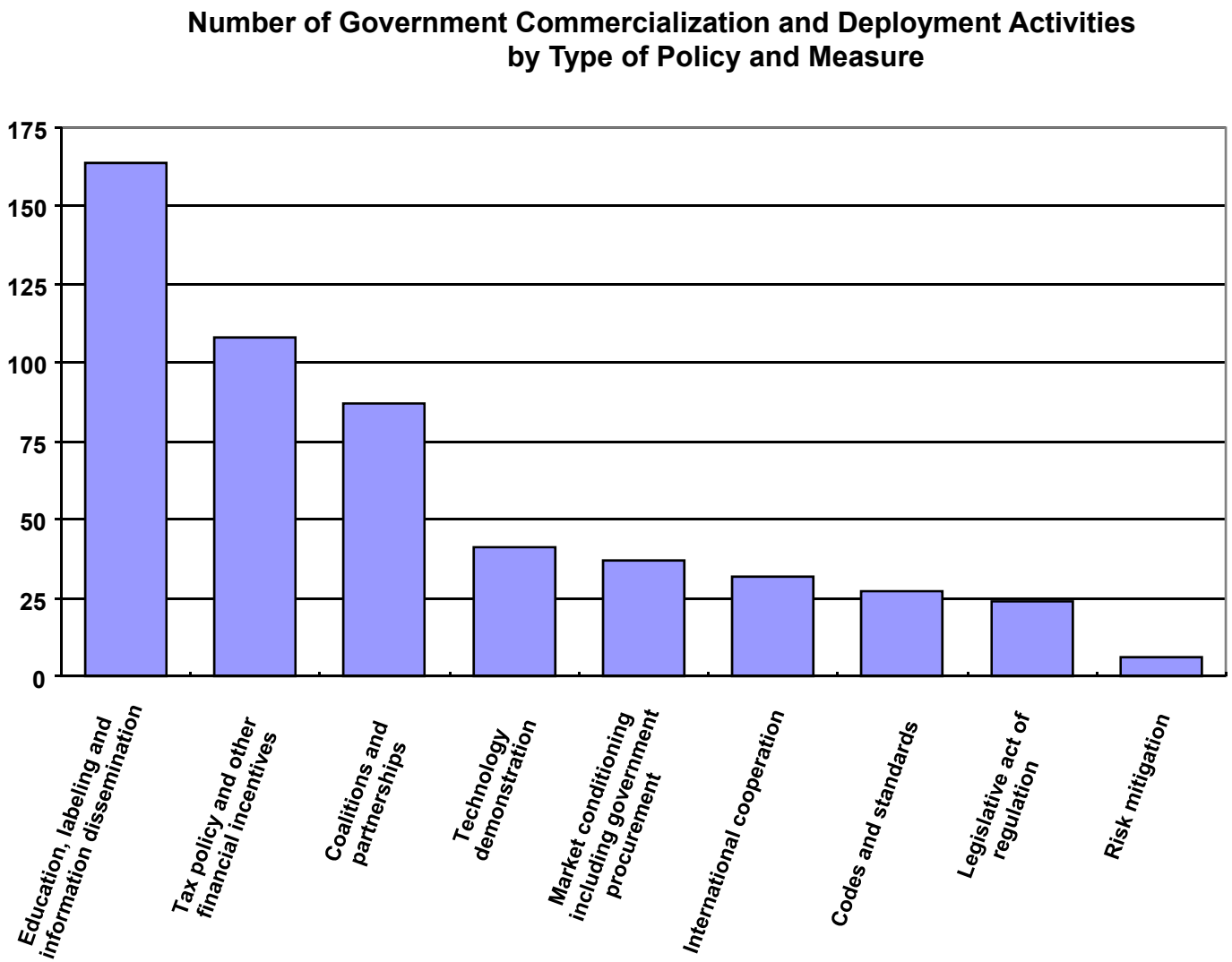
6 Barrier Categories
21 Barriers
~50 Detailed Barriers

Barriers are organized into six categories consistent with EPAct 2005 Title XVI.

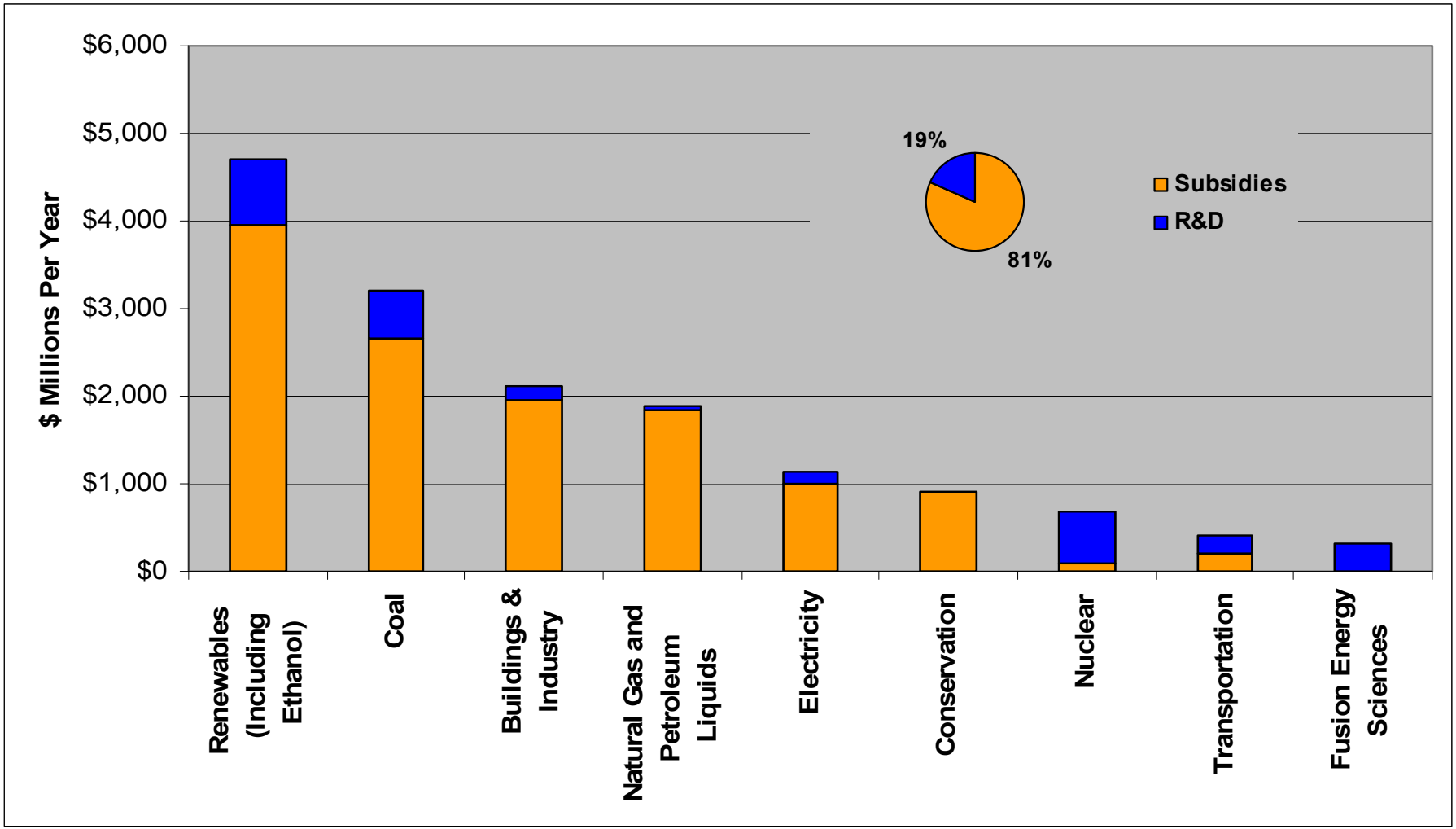
Commercialization and Deployment Activities, by Technology Area



Commercialization & Deployment Activities, by Category or Genre



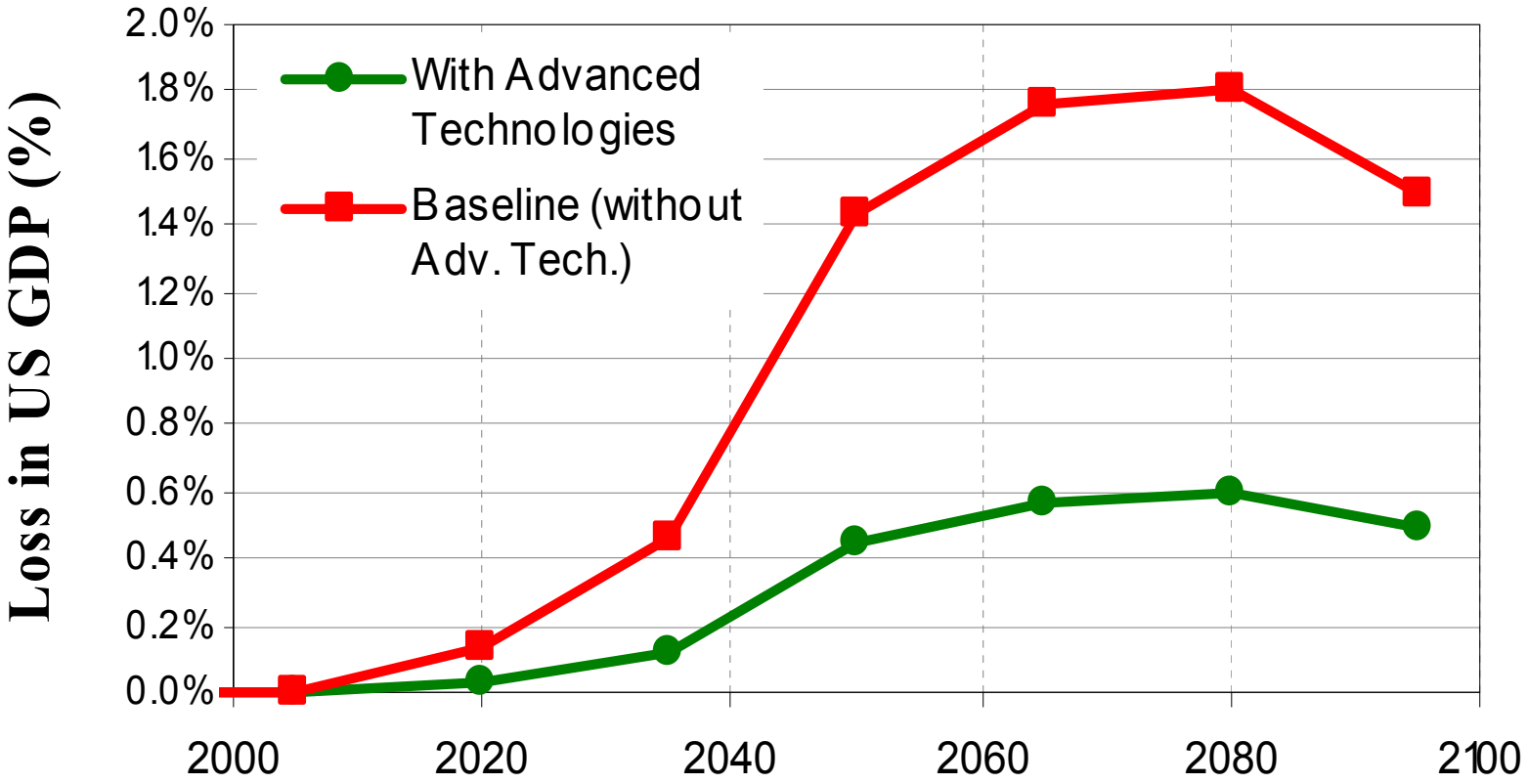
Federal Subsidies on Energy, FY 2007



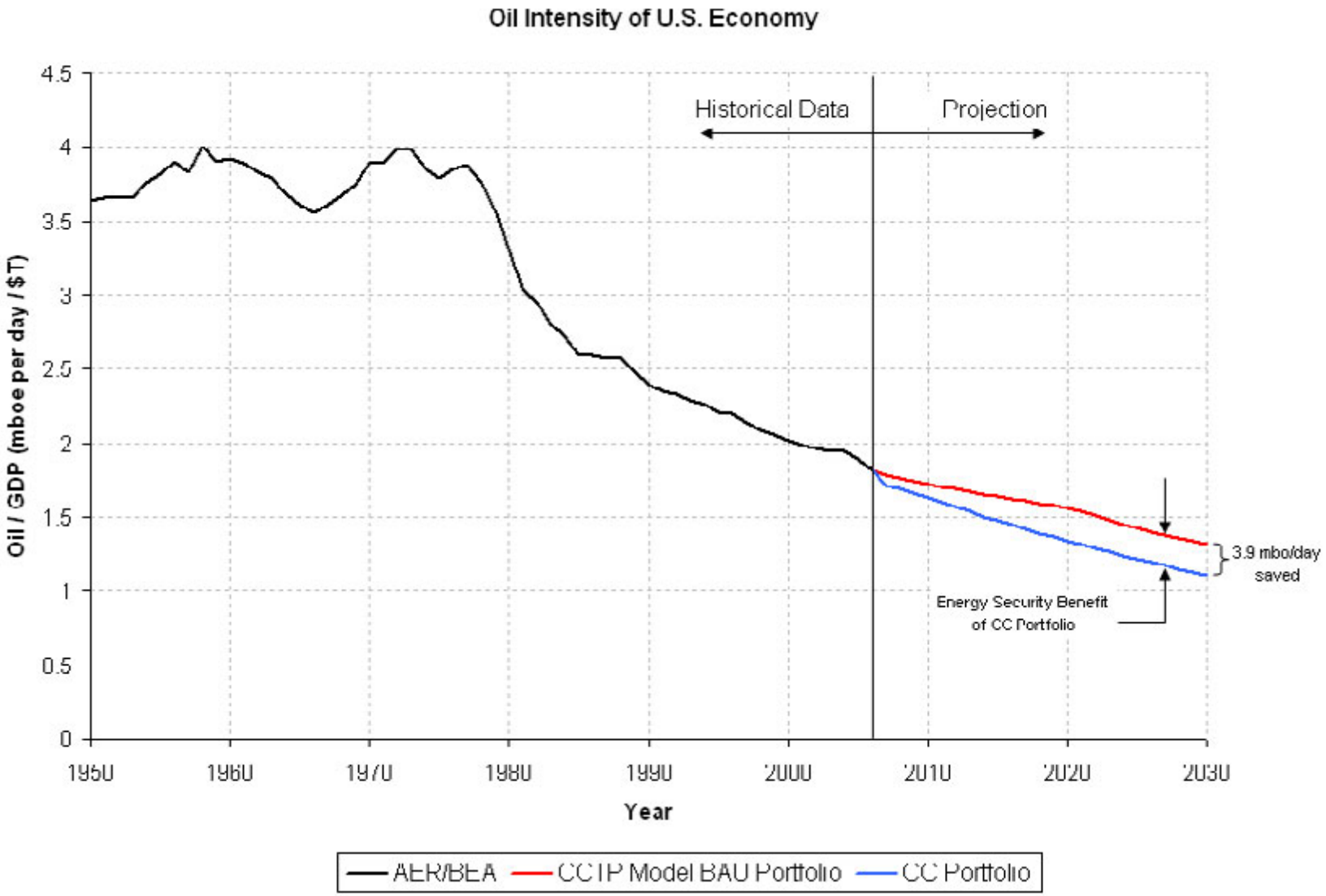
Sources: R&D data are from the Federal Climate Change Expenditures Report (2007). Subsidy data are from the Energy Information Administration analysis of tax expenditures, U.S. Treasury (2007).

Economic Benefits of Advanced Technology

Cost to U.S. Economy of Achieving 450 ppm Emissions Trajectory, with and without Advanced Technologies



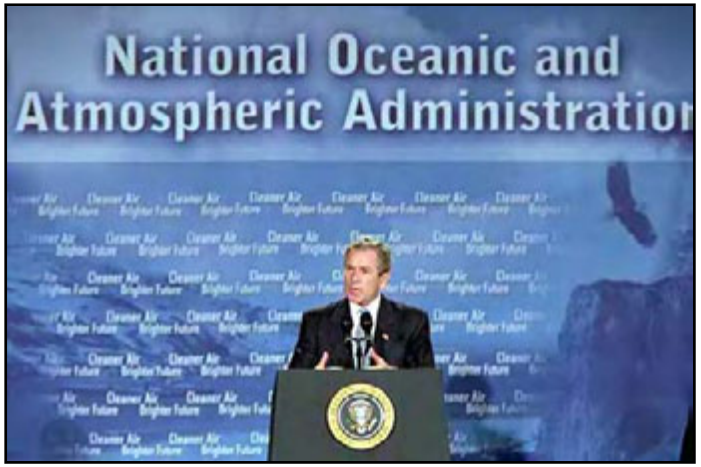
Energy Security Benefits



International Cooperation

International Cooperation: Key Component of U.S. Climate Change Policy

- *"I am today committing the United States of America to work within the United Nations framework and elsewhere to develop with our friends and allies and nations throughout the world an effective and science-based response to the issue of global warming."—President Bush, June 11, 2001*
- *"I will intend to work with nations, especially the poor and developing nations, to show the world that there is a better approach, that we can build our future prosperity along a cleaner and better path."*
  —President Bush, February 14, 2002



Principles for Effective International Action

Climate Change, Clean Energy and Sustainable Development

- **The U.S. Is Guided by the Following Principles:**
  - **Climate change is a serious long-term issue, requiring sustained action over many generations by both developed and developing countries.**
    - ✓ **Developing innovative technologies that are cleaner and more efficient is the key to addressing our climate challenge.**
  - **We oppose any policy that would achieve reductions by putting Americans out of work, or by simply shifting emissions from one state to another, or from the U.S. to another country.**
    - ✓ **Like us, developing countries are unlikely to join in approaches that foreclose their own economic growth and development.**

U.S. Climate Change Bilaterals

Innovative International Technology 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.

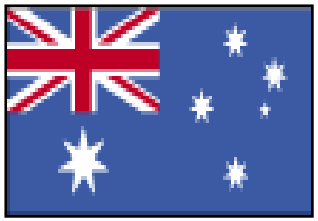
ITER: 7 members; project to develop fusion as a commercial energy source.

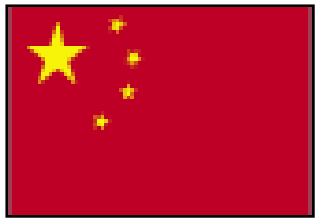
Methane to Markets: 17 members; recovery and use of methane from landfills, mines, oil & gas systems, and agriculture.

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

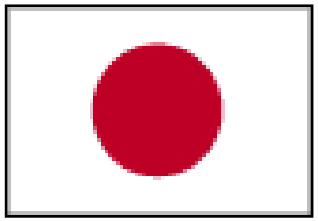
Global Nuclear Energy Partnership: Seeks worldwide consensus on enabling expanded use of nuclear energy using a nuclear fuel cycle that enhances energy security, while promoting non-proliferation.

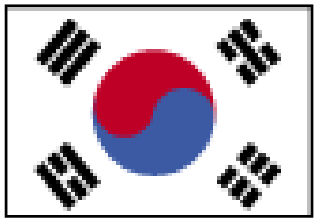
Asia-Pacific Partnership on Clean Development and Climate

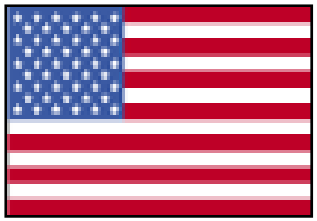

Australia


China


India

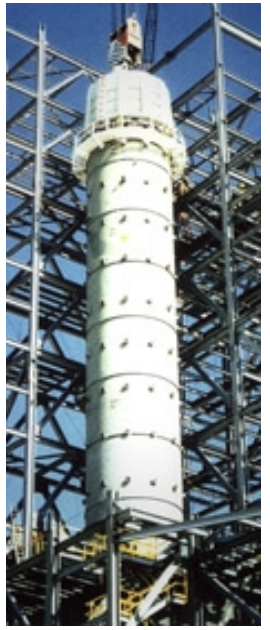

Japan


Republic of Korea


United States

Focus: Vision Statement for APP

- Undertake voluntary practical measures to create new investment opportunities, build local capacity, and remove barriers to the introduction of clean, more efficient technologies.
- Help each country meet nationally designed strategies for improving energy security, reducing pollution, and addressing the long-term challenge of climate change.
- Promote the development and deployment of existing and emerging cleaner, more efficient technologies and practices that will achieve practical results in areas such as:



- Energy Efficiency
- Clean Coal
- Natural Gas
- Bioenergy
- Methane Capture/Use
- Civilian Nuclear Power
- Geothermal
- Agriculture/Forestry
- Rural/Village Energy Systems
- Advanced Transportation
- Hydro/Wind/Solar Power
- Building & Home Construction

Major Economies Process

Complements, Does not Supplant, Central Role of the UNFCCC and the 1992 Treaty

Designed to Facilitate Cooperation Among 17 Major Emitters

Focused on:

- Climate Change and Energy Security
- Environmental Effectiveness and Economic Sustainability
- Mitigation and Adaptation
- National Circumstances and Global

Initial Emphasis:

- Land Use
- Technology
  - » Low-Carbon Fossil Power
  - » Transportation
  - » Efficiency
- Market Penetration
- Financing

"Energy security and climate change are two of the great challenges of our time. The United States takes these challenges seriously. The world's response will help shape the future of the global economy and the condition of our environment for future generations. The nations in this room have special responsibilities."
President George W. Bush
September 28, 2007

Major Economies Represented		
Australia	Germany	Mexico
Brazil	India	Russia
Canada	Indonesia	South Africa
China	Italy	UK
EU / EC	Japan	United States
France	Korea	UN / IPCC*

* Observers

Path Forward

Summary -- A Path Forward Involves …

A Visionary Long-Term Approach, Based on Innovation, Growth and International Cooperation

Continued Leadership from the Top

Near-Term Actions – Voluntary, Augmented by Financial Incentives

Progress in Climate Change Science Will:

- **Reduce Uncertainty and Illuminate Risks and Benefits**
- **Add Relevance and Specificity to Assist Decision-Makers**

Progress in Climate Change Technology Will:

- **Create New, Better, and More Affordable Solutions**
- **Facilitate Means for Change and Smooth Transition**

Expanded Opportunities for Cooperation Among:

- **Business, Industry, States and NGOs**
- **Research Institutions and Academia**
- **Major Economies, Under G8 Leadership**
- **Cooperative Frameworks with S&T Actions Abroad**

Will Build a Bridge to Low-Emissions Future with Broad Support