The National Academies
Summit on America's Energy Future

Advancing Climate Change Technology -- The Key to Multi-Goal Convergence

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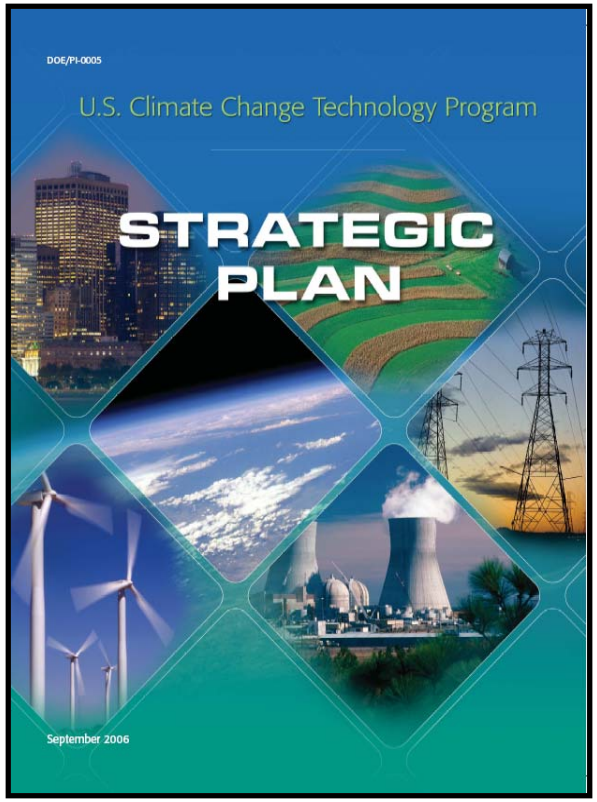
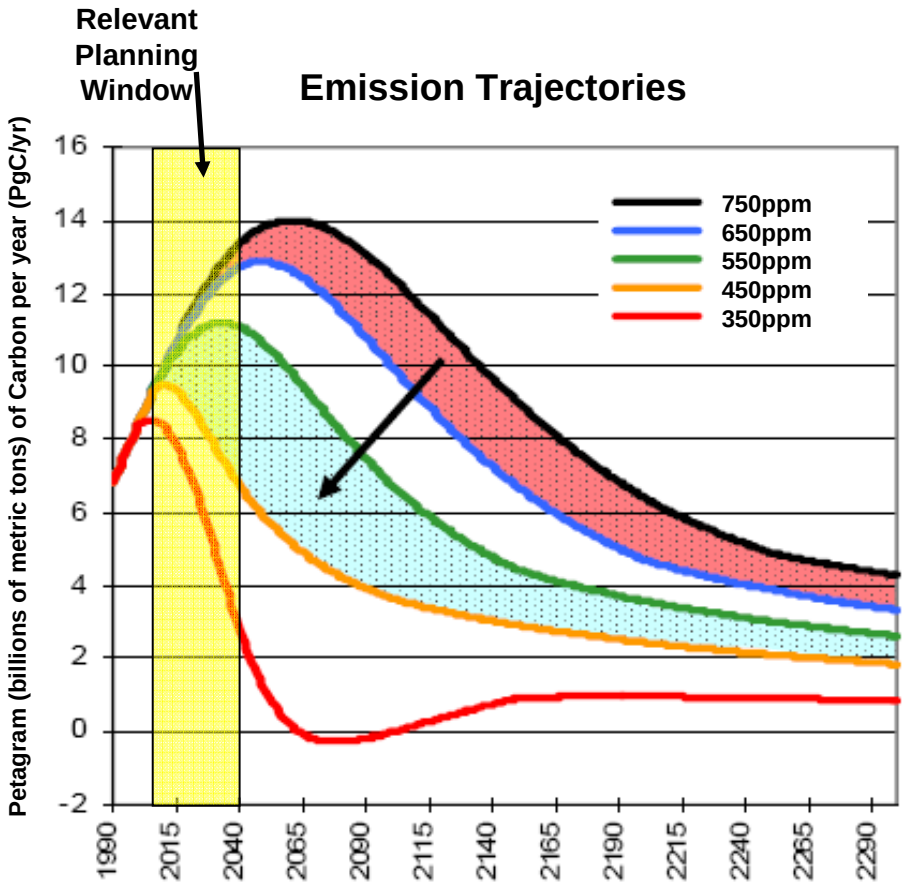
U.S. Climate Change Technology Program

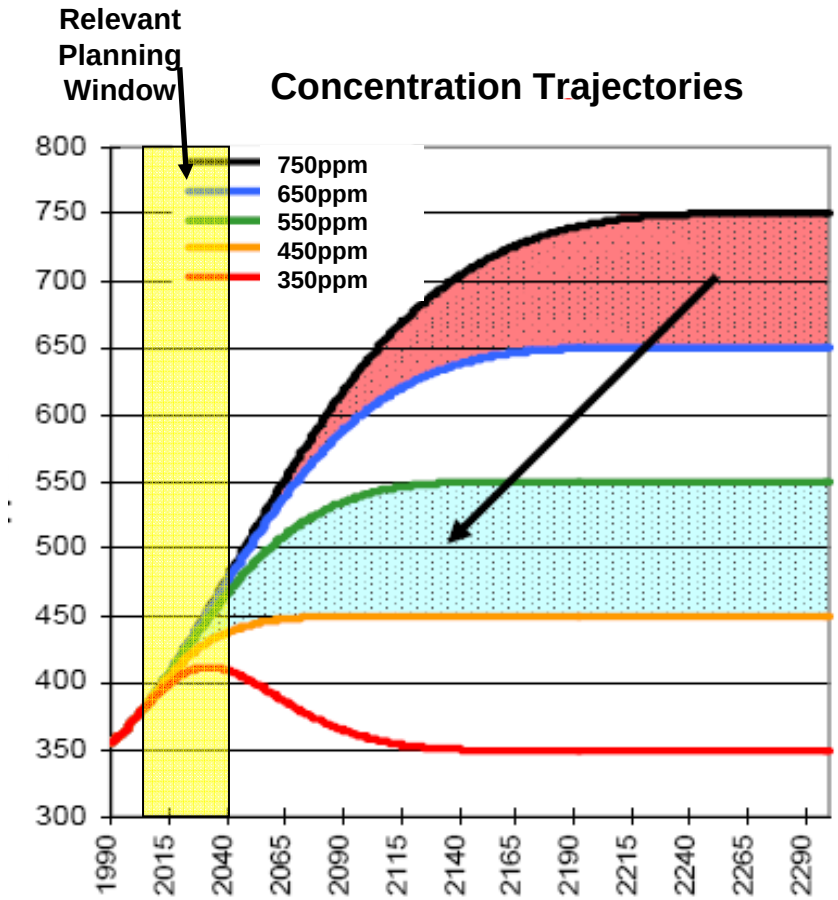
- **U.S. Climate Change Technology Program**
  - Mission – Accelerate RD&D on Adv. CC Techs
  - Scope – Ten Federal R&D Agencies
  - Budget -- $4.4 Billion Requested for FY'09
  - Activities – Coord.RD&D Planning & Budgeting
- **Goals:**
  - Four emissions-related strategic goals:
    - ✓ Reduce emissions from energy end use & infrastructure;
    - ✓ Reduce emissions from energy supply;
    - ✓ capture & sequester CO_2; and
    - ✓ Reduce emissions from non-CO_2 gases.
  - Two cross-cutting, supporting strategic goals:
    - ✓ Improve capabilities to measure & monitor GHGs; and
    - ✓ Bolster basic science and strategic research.
- **CCTP authorized in *EPAct2005*. Led by DOE.**



www.climatetechnology.gov

Technical Goals Set Within Context of United Nations Framework Convention on Climate Change





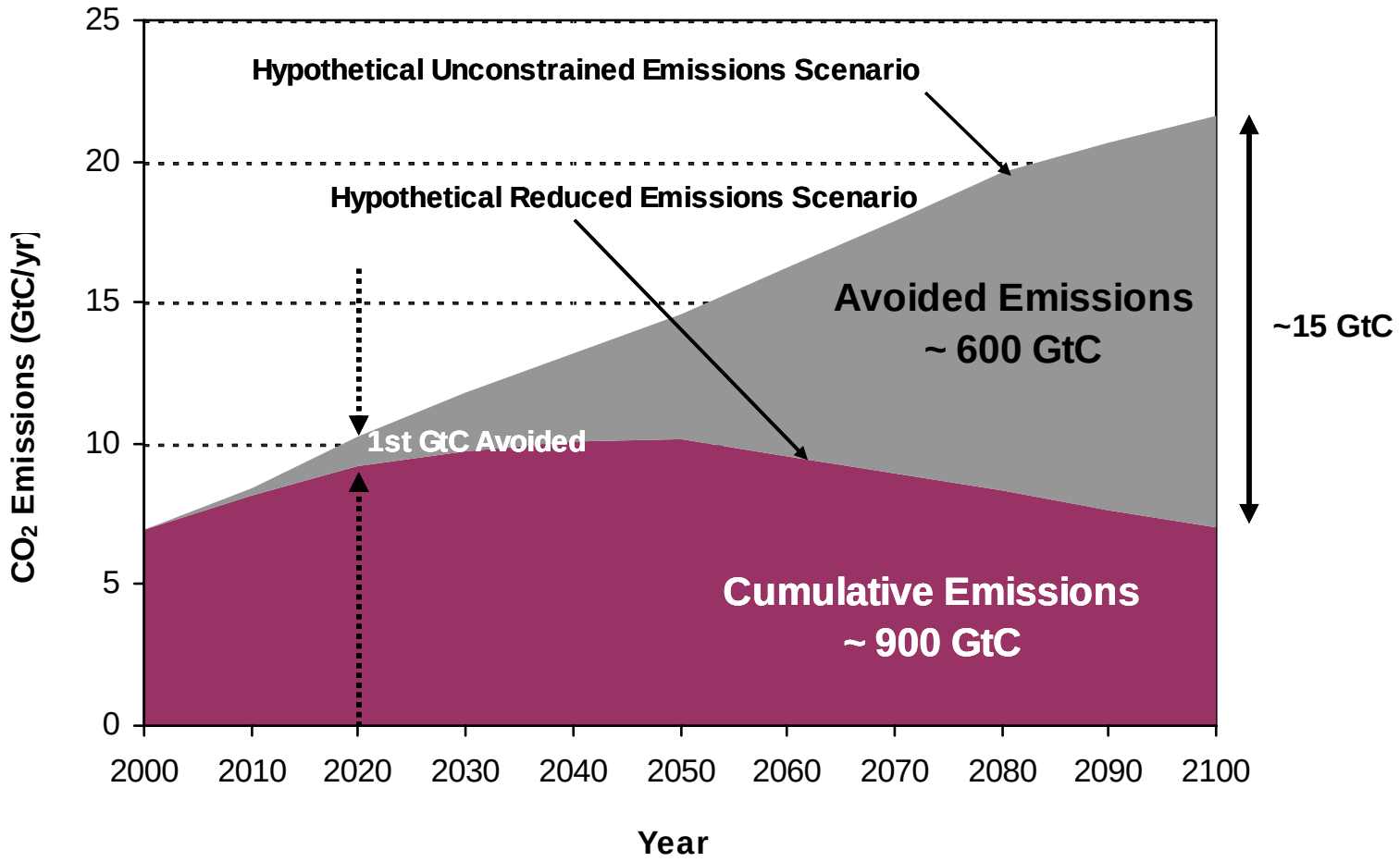
Emission and concentration trajectories based on level of effort for technology investments

Potential carbon reductions based on more aggressive technology investments

Relevant planning window to influence longer-term outcomes

Wigley, Richels, Edmonds, Nature, 1996

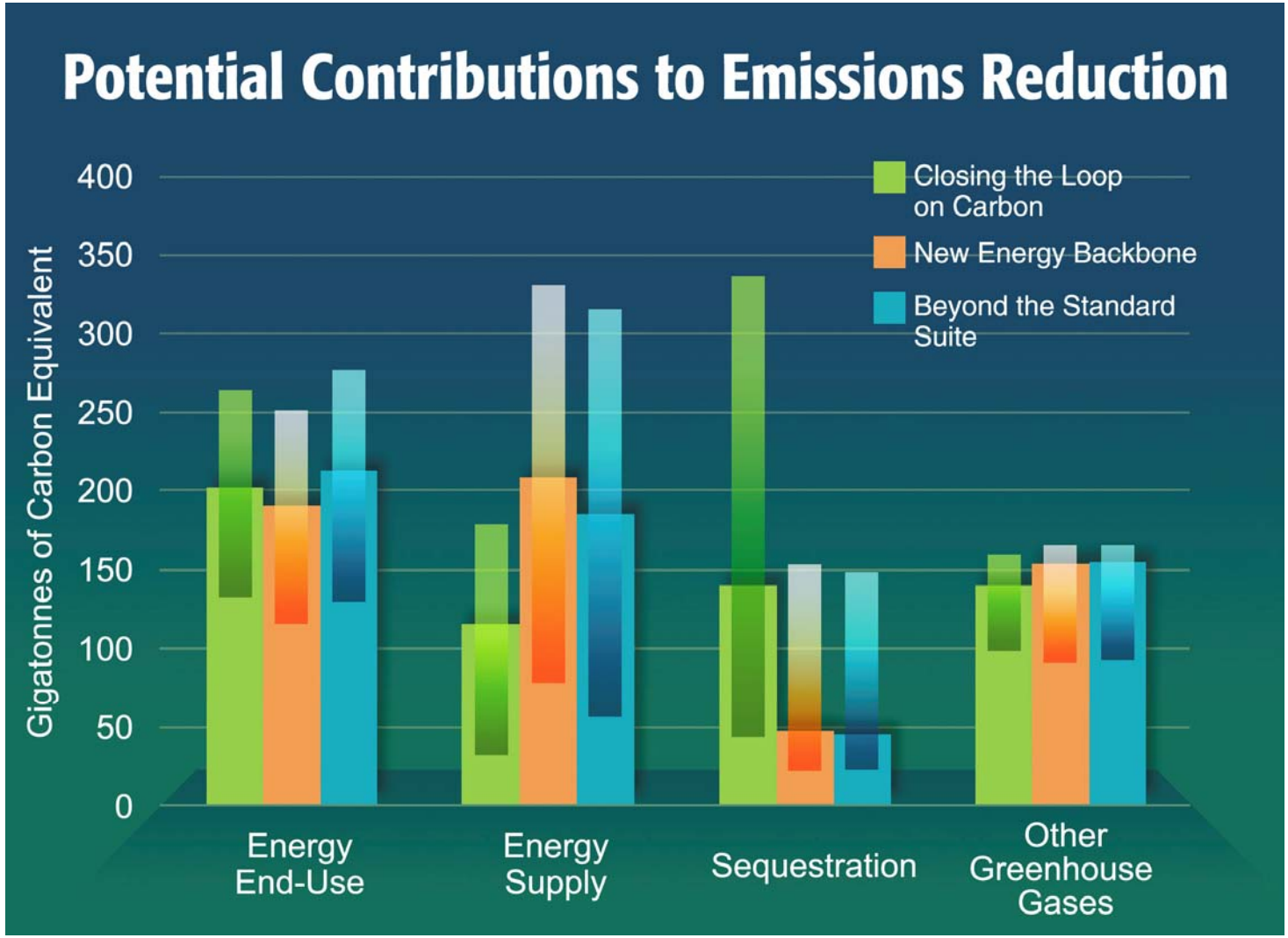
The Technical Challenge – Reduce GHGs Toward Near Net-Zero Emissions Future



GtC = Giga-Tonnes Carbon

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

Results of An Integrated Assessment



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.

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)

Technology Strategy

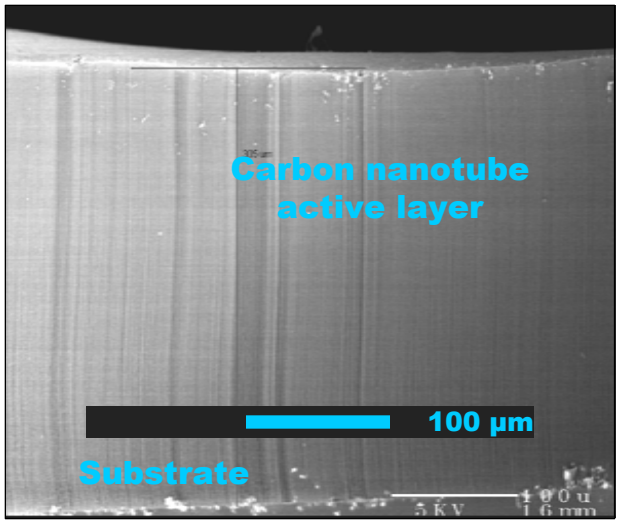
"Energy security and climate change are two of the great challenges of our time. These challenges share a common solution: technology."

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

- **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
    - » Alternatives, including Other Modes
  - Efficiency (All Sectors)
  - Other GHGs
  - Enablers
    - » CO_2 Capture and Storage
    - » Modernized Grid
    - » Energy Storage, Large and Small Scale
    - » Strategic and Exploratory Research
- **Supporting Policies to Promote Deployment**
  - Financial Incentives
  - Fuel Mandates
  - Codes, Standards, Labeling
  - Transparent System for Measuring Progress
- **Via U.S. Climate Change Technology Program**
  - Strengthen Federal R&D Portfolio
  - Prioritize Investments
- **Expand R&D Cooperation with non-Federal Entities**

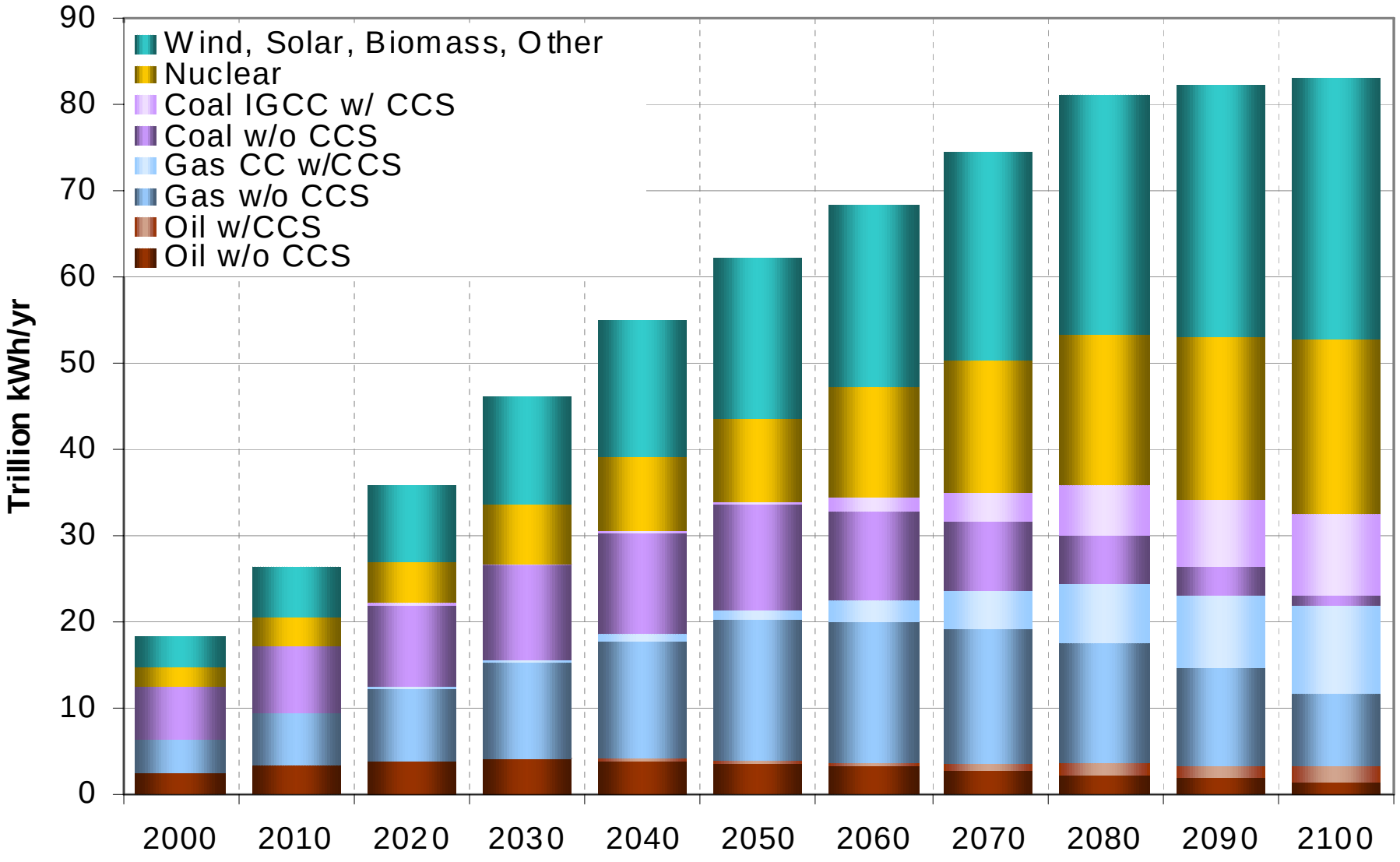
"De-Oil" Transportation

- **Future Transport System**
  - **Multi-Modal**
  - **Regional Choices**
  - **Coordinated Integrated Land-Use Planning**
- **Vehicle Options**
  - **Electric Vehicles**
  - **Hybrid Vehicles**
  - **Bio-Based Vehicles**
  - **H2 & Hydrogenated Molecules**
  - **Oil & Gas Vehicles**



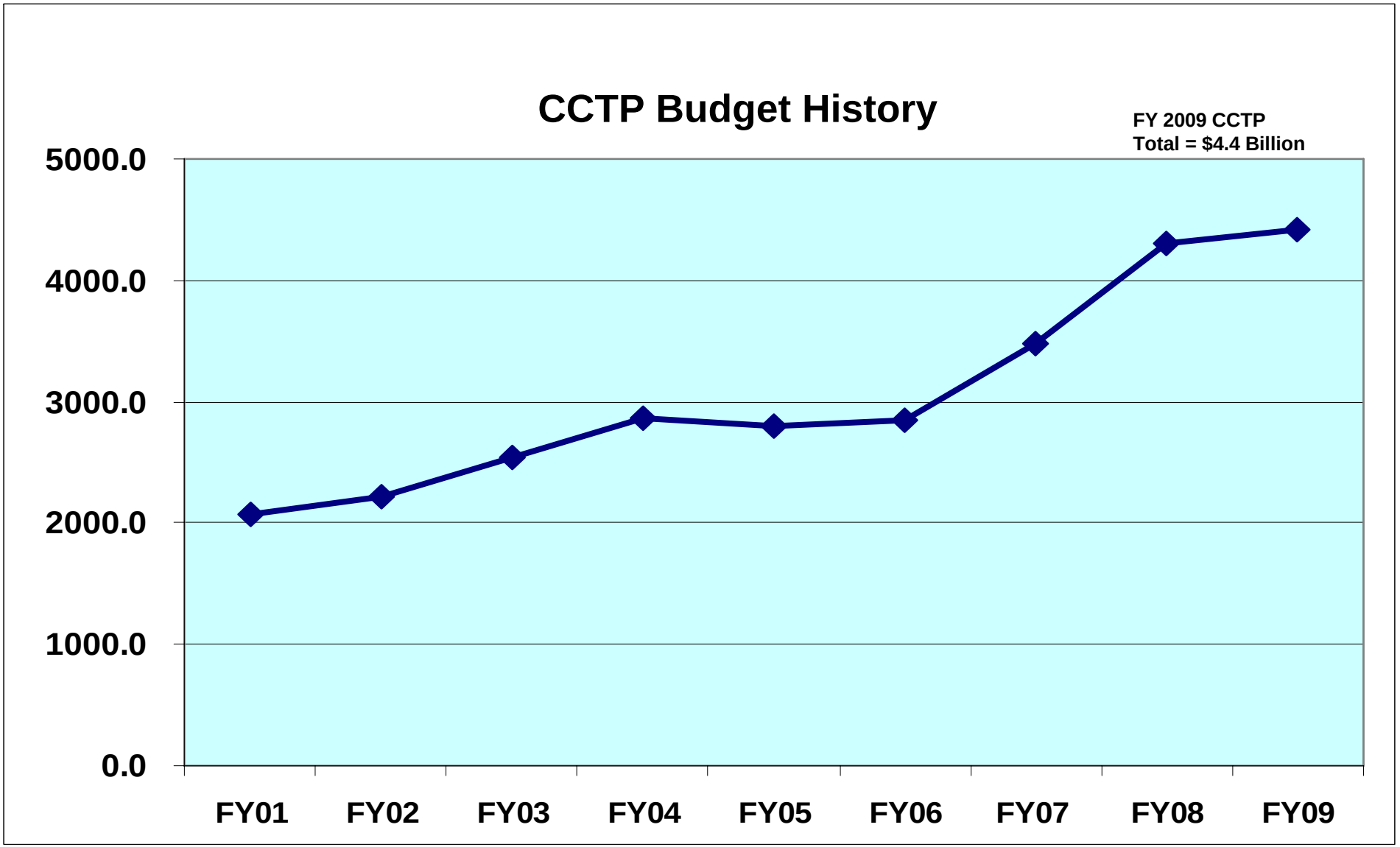
Nanotube-Enhanced Ultracapacitor
[MIT, R. Signorelli – March 2005]

“De-Carbonize” the Electric Grid



March 14, 2008

FY 2009 Budget – Good News



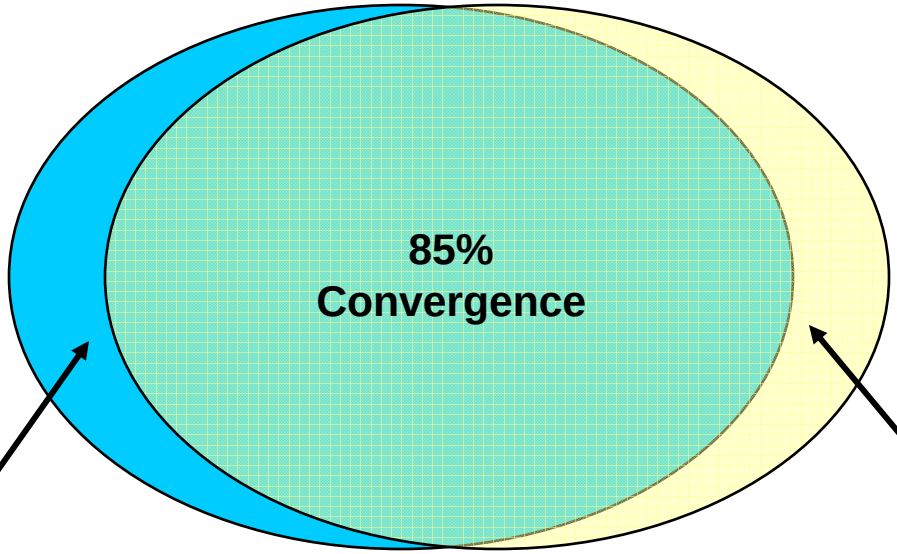
Technology Area Highlights

- **Energy Efficiency [$550M] -- *Accelerated RD&D to Reduce GHG Emissions***
  - **Vehicles: $221M**
  - **Buildings: $124M**
- **Renewables [$705M] -- *Increases in Biofuels and Geothermal***
  - **Biomass & Biorefinery Systems R&D: $225M**
  - **Geothermal Technology: $30M**
  - **Solar: $156M**
  - **Wind: $53M**
  - **Hydrogen Fuel Initiative: $267M**
- **Coal [$744M] -- *Largest Budget Request in Over 25 Years***
  - **FutureGen: $156M**
  - **CCS: $149M**
  - **Clean Coal Power Initiative: $85M**
- **Nuclear [$879M] -- *Increases to Spur First New Plants***
  - **Nuclear Power 2010: $242M**
  - **Advance Fuel Cycle Initiative: $302M**
- **Electricity Delivery [$122M] -- *Increases in Energy Storage***
  - **Energy Storage & Power Electronics: $13M**
  - **Energy Storage R&D: $34M (Office of Science)**
  - **Distributed Energy: $33**

Hypothesis

- America's "Energy Future" Aspires to Attain Multiple Goals:
  - Economic Growth and Prosperity
  - Quality of Life, Health and Respect for the Environment
  - Clean, Reliable, Affordable Energy Supply
  - National Security and Global Stability
  - Climate Protection
- These Goals Are Inextricably Intertwined
  - They Can Be, But Are Not Fundamentally, in Conflict
- The "Long-Pole" in the Tent is Climate Change
- If Society Were to Transform Itself to Meet the UNFCCC's Goal
  - It Would Achieve Climate Protection, and
  - See "Convergence" in the Attainment of the Other Goals

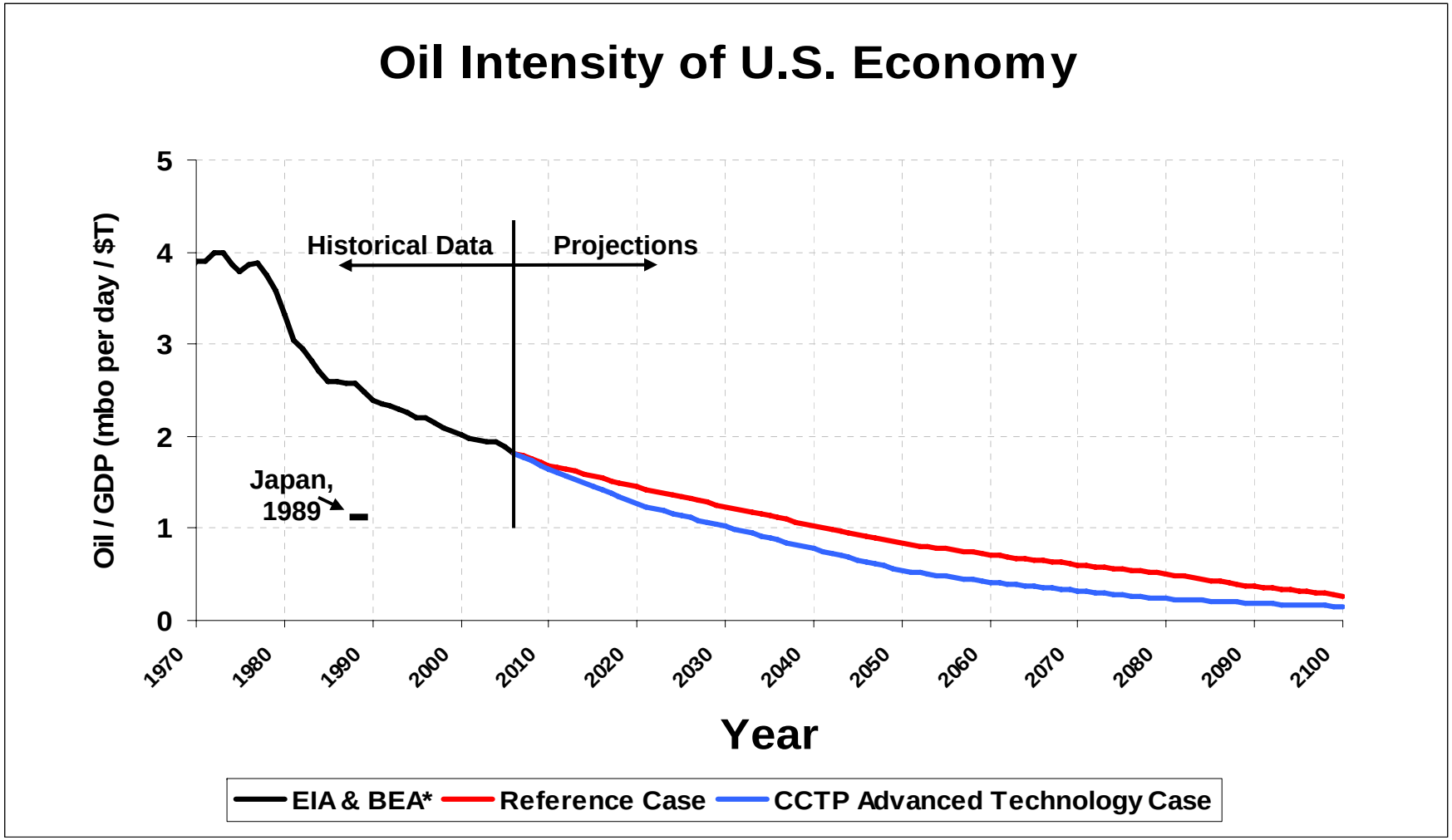
America's Energy Future is Linked to Solutions for Climate Change



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

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

Energy Security Metric Under Least-Cost Advanced Technology Climate Change Scenarios

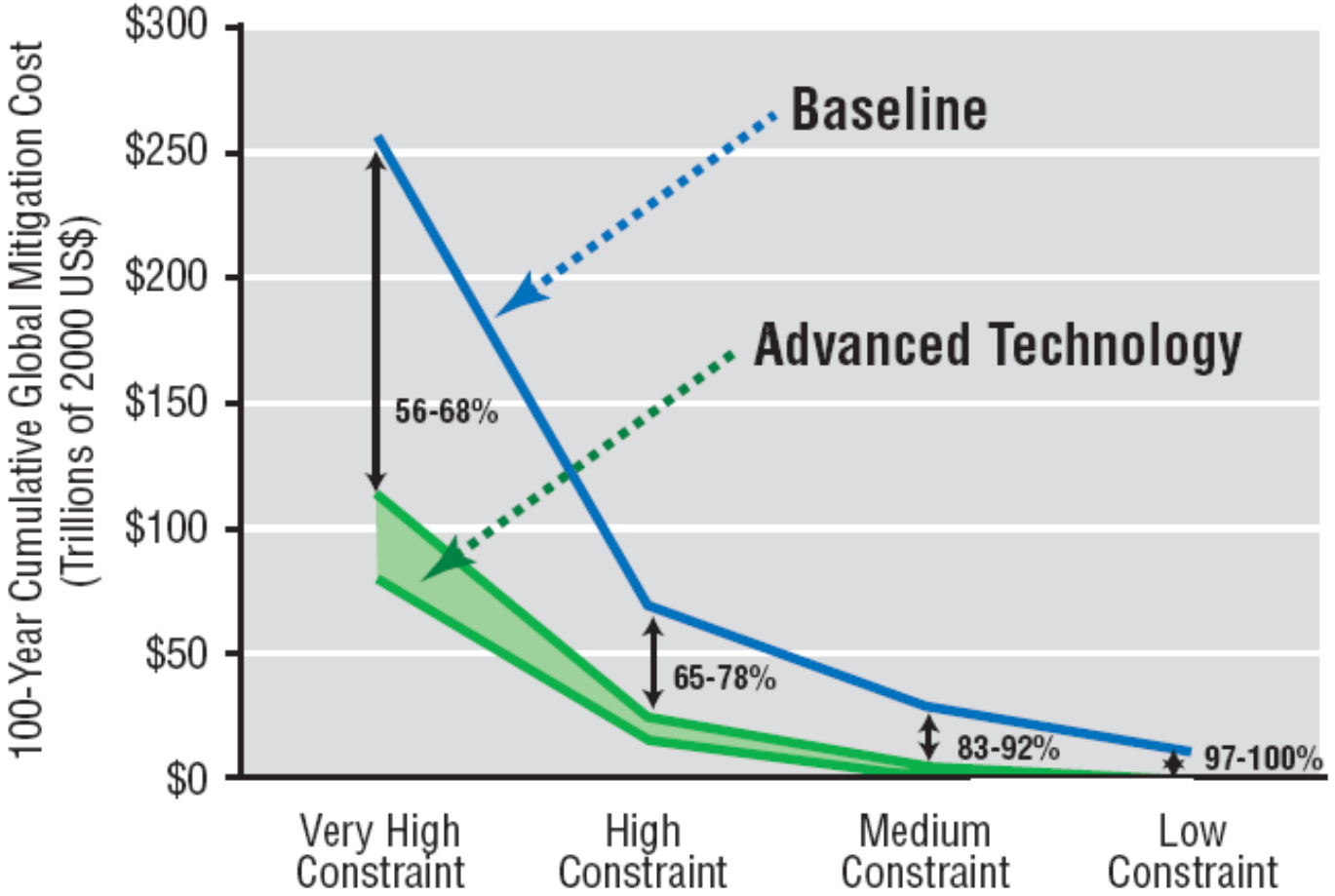


*** Sources:**

1) Energy Information Agency & Bureau of Economic Analysis
2) DOE National Energy Strategy, 1991, Figure 2
3) CCSP, Synthesis and Assessment Product 2.1, Scenarios of Greenhouse Gas Emissions and Atmospheric Concentrations, Oct. 2007
4) Clark et. all, "Climate Change Mitigation: An Analysis of Advanced Technology Scenarios," PNNL-16078, September 2006, (Addendum added April 2007

Costs Must Be Lowered Significantly

Comparative Analysis of Estimated Cumulative Costs Over the 21st Century of GHG Mitigation, With and Without Advanced Technology, Across a Range of Hypothesized GHG Emissions Constraints.*



*** U.S. Climate Change Technology Program Strategic Plan, September 2006, Figure 10-2**

Timing is of the Essence

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.

Key Barriers

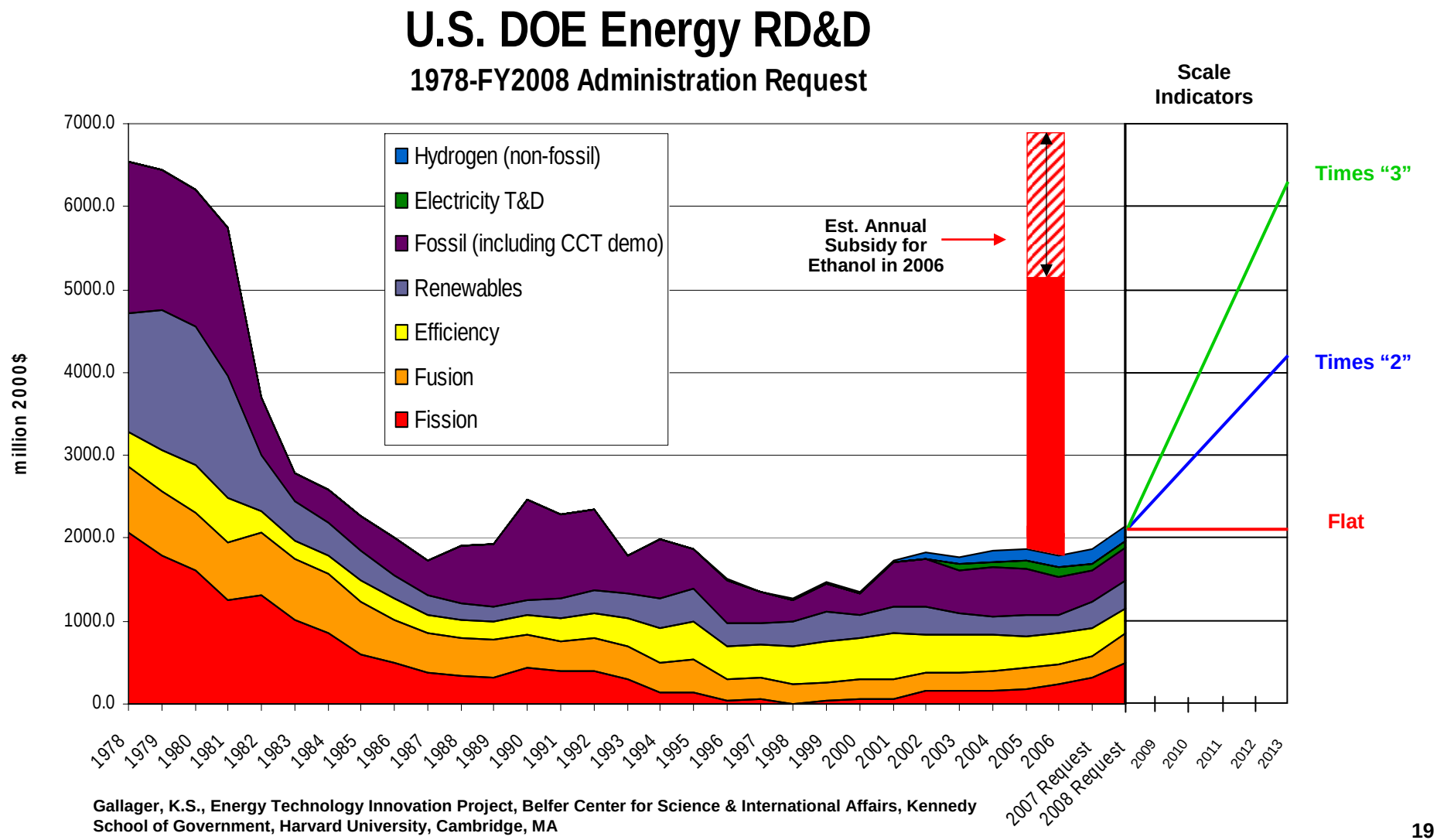
- **Level of Global RD&D Investment**
  - Pace of Progress Likely Too Slow
  - U.S. Federal RD&D is Increasing, but Constrained
  - Only Two Countries (U.S., Japan) Account for 80 Percent
  - Other Government's RD&D Decreasing
- **Market Signals to Motivate Private Innovation & Invest.**
  - Many Near-Term Measures, Incentives, Mandates
  - But Private Sector Incentives Are Limited w/Out Market Signals
  - How Best to Internalize CC "Externalities"
  - Needed Prices May Be Too High w/Out Innovation
  - Compromise Prices May Be Too Low to Spur Innovation
- **International Framework for Burden Sharing**
  - The Ultimate Goal is "Net-Zero" Emissions
  - Global Participation is Essential
  - Need for Realistic Goals and Commitments
  - Measurement, Reporting and Verification
  - Issues of Equity and Leakage
  - Finance and Trade in Environmental Goods & Services

RD&D

CCTP Strategic Goal		Key Element of Strategy	CCTP Strategic Plan -- Corresponding Technologies in Scenarios 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	$MtCO_2$/yr	371	530	687	858	1,247					
	1.2	Buildings	Primary Energy Reduction	EE	BSS 450	$MtCO_2$/yr	157	275	388	501	543					
	1.3	Industry	Primary Energy Reduction	EE	BSS 450	$MtCO_2$/yr	443	641	775	878	652					
	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	$MtCO_2$/yr	69	192	401	689	1,208					
			Electricity: Natural Gas w/CCS	FE	CLC 450	$MtCO_2$/yr	60	148	311	541	954					
	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	$MtCO_2$/yr	0	9	59	164	216					
			Electricity: Wind Power	EE	NEB 450	$MtCO_2$/yr	11	89	237	421	476					
			Bio-Based Fuels	EE	BSS 450	$MtCO_2$/yr	0	8	56	168	214					
	2.4	Nuclear Fission	Electricity: Gen III Reactors	NE	NEB 450	$MtCO_2$/yr	33	183	472	864	1,339					
			Electricity: Gen IV Reactors	NE	NEB 450	$MtCO_2$/yr	0	14	77	207	556					
			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	$MtCO_2$/yr	0	0	44	163	1,287					
3 Capturing and Sequestering Carbon Dioxide	3.1	Carbon Capture	(Embedded in 2.1)	FE	N/A	N/A	TBD									
	3.2	Geological Storage	Carbon Storage	FE	CLC 450	$MtCO_2$/yr	130	341	726	1,285	2,237					
	3.3	Terrestrial Sequestration	TBD	USDA	TBD	$MtCO_2$/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	$MtCO_2$-Eq/yr	TBD									
	4.2	Methane and Nitrous Oxide Emissions from Agriculture	TBD--CH_4 (Part)	USDA	CLC 450	$MtCO_2$-Eq/yr	TBD									
			TBD--N_2O (Part)	USDA	CLC 450	$MtCO_2$-Eq/yr	TBD									
	4.3	Emissions of High Global-Warming Potential Gases	Short-Lived F-Gases in CO_2-Equivalence	EPA	CLC 450	$MtCO_2$-Eq/yr	TBD									
			Long-Lived F-Gases in CO_2-Equivalence	EPA	CLC 450	$MtCO_2$-Eq/yr	TBD									
	4.4	Nitrous Oxide Emissions from Combustion and Industrial Sources	N_2O in CO_2-Equivalence	EPA	CLC 450	$MtCO_2$-Eq/yr	TBD									
	4.5	Emissions of Tropospheric Ozone Precursors and Black Carbon	TBD	EPA	TBD	$MtCO_2$-Eq/yr	TBD									
5 Enhancing Capabilities to Measure and Monitor Greenhouse Gasses	5.2	MM -- Energy Production and Efficiency	N/A	DOE			Refer to Strategic Plan, Chapter 8									
	5.3	MM -- CO_2 Capture and Sequestration	N/A	DOE			Refer to Strategic Plan, Chapter 8									
	5.4	MM -- Other Greenhouse Gases	N/A	EPA			Refer to Strategic Plan, Chapter 8									
	5.5	MM -- Integrated Systems Architecture	N/A	SC			Refer to Strategic Plan, Chapter 8									
6 Bolster Basic Science Contributions to Technology Development	6.1	Strategic Research	N/A	SC			Refer to Strategic Plan, Chapter 9									
	6.2	Fundamental Science	N/A	SC			Refer to Strategic Plan, Chapter 9									
	6.3	Exploratory Research	N/A	SC			Refer to Strategic Plan, Chapter 9									

* In view of various hypothetical RD&D portfolios and other factors. Check marks are representational of the process and should not be construed as results of extant situations.
Key: Very Likely (90-100%); Likely (60-90%); Maybe (40-60%); Unlikely (10-40%); Very Unlikely (0-10%)

Historical Perspective on DOE Spending

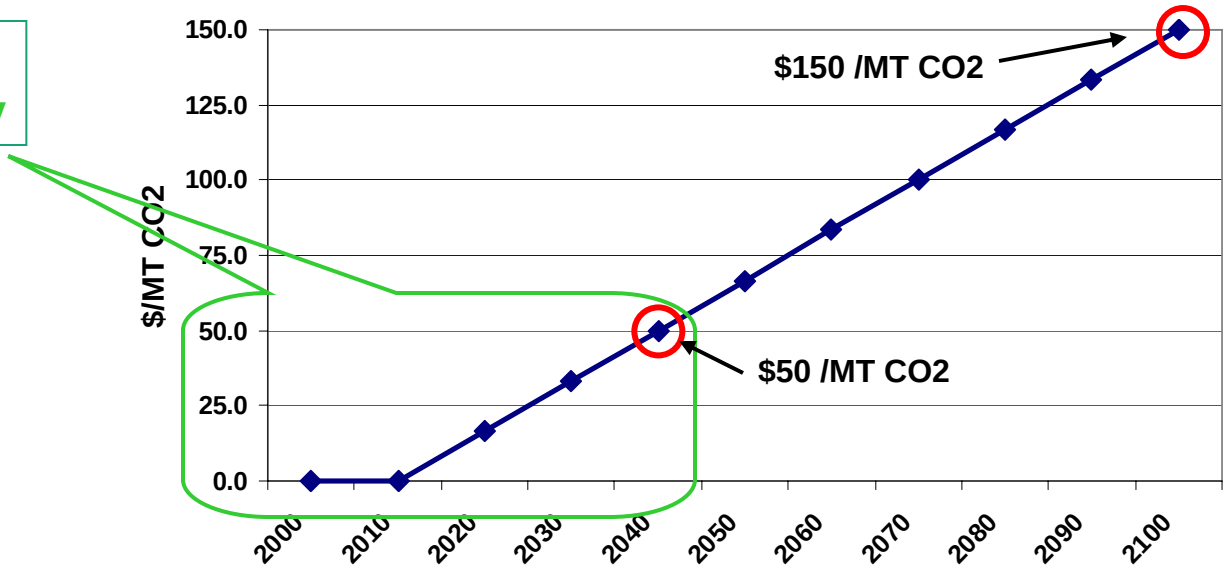


Gallager, K.S., Energy Technology Innovation Project, Belfer Center for Science & International Affairs, Kennedy School of Government, Harvard University, Cambridge, MA

Incentives for Transformational Innovation

Inferred Value on Avoided Emissions

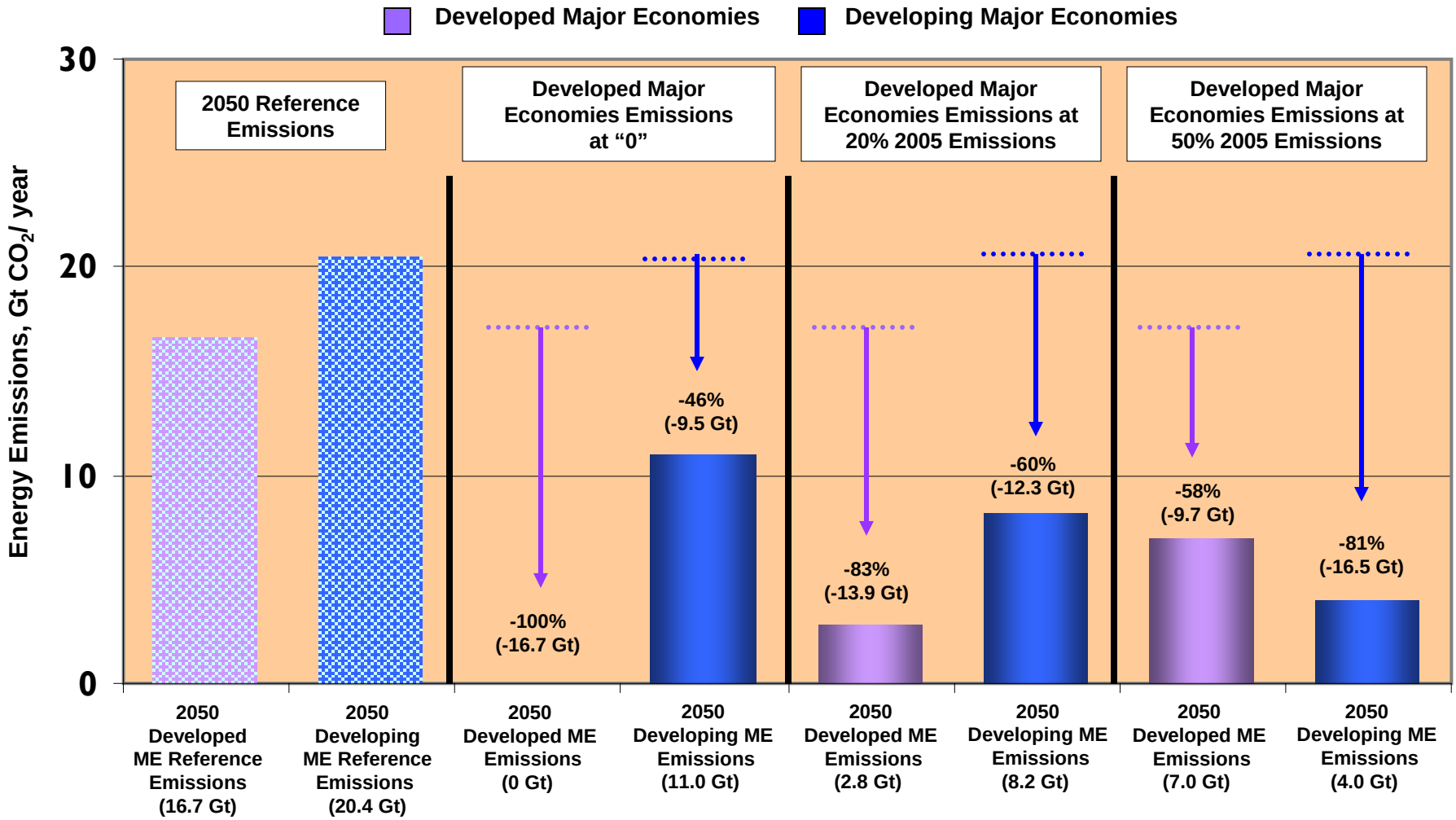
Bridge Strategy



Incremental % Price Increase

	2004 Price	% Increase at: $10/ MT-CO2	% Increase at $50/ MT-CO2
Electricity (kwh)	$0.076	2.3%	8.2%
Gasoline (Gal)	$1.90	1.3%	4.6%
Coal (S-Ton)	$27.30	19%	70%
Natural Gas (mcf)	$10.74	1.4%	5.1%

Energy CO_2 Emissions Reductions Needed in 2050 for Major Economies[1] to Achieve a Combined 50% Reduction in Emissions Below 2005[2] Levels



[1] Equals reduction from the 2050 reference case for that ME group (*i.e.*, Developed or Developing). Developed MEs include: U.S., Europe, Russia, Japan, Canada, South Korea, and Australia. Developing MEs include: China, India, South Africa, Mexico, Brazil, and Indonesia.

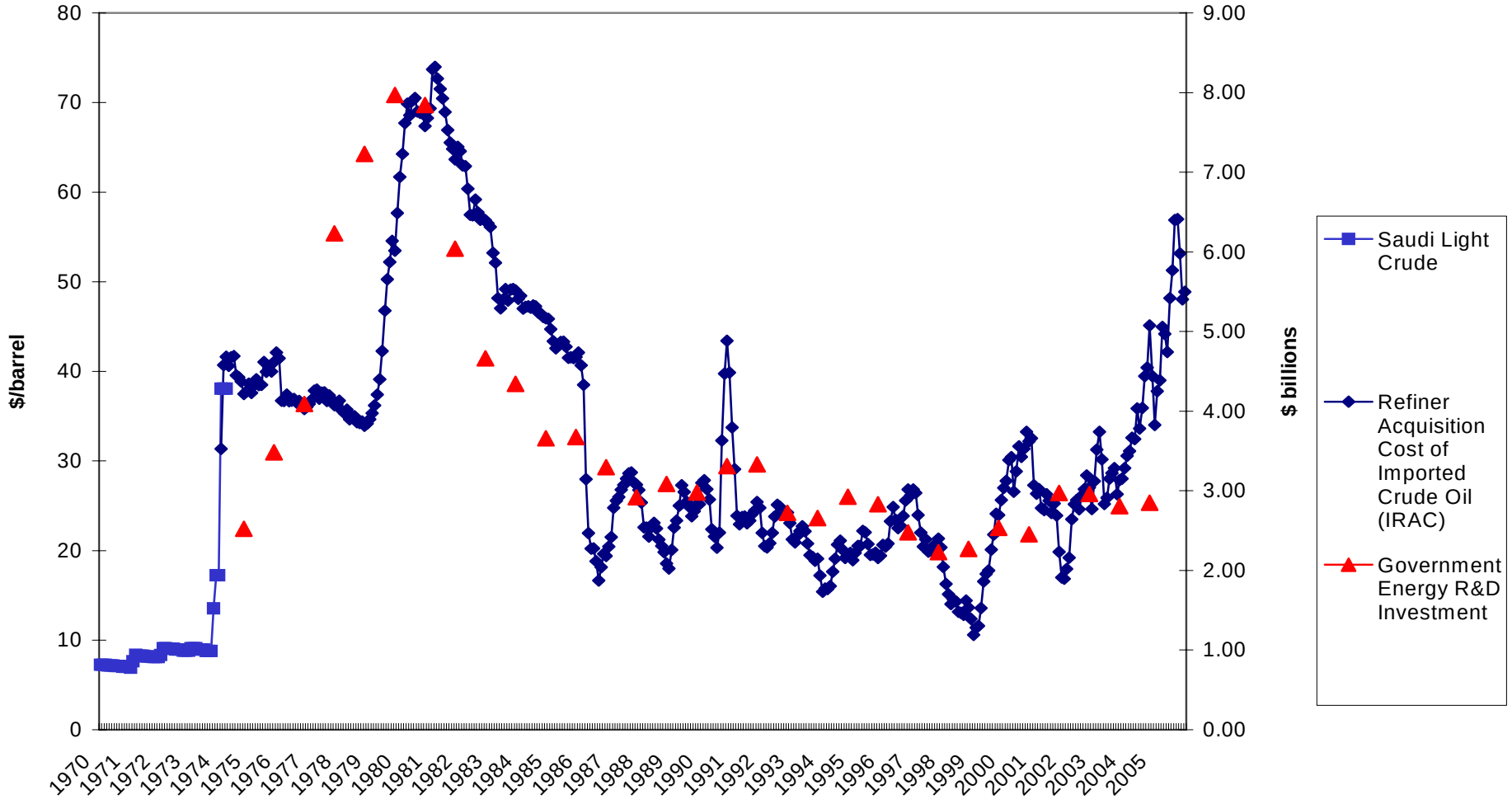
[2] 50% of 2005 total Major Economies energy CO_2 emissions equals 11.0 Gt.

Challenges

- **How to Lift Global RD&D Investment?**
  - More U.S. RD&D?
  - More International RD&D?
  - More Private Sector RD&D?
  - Technology Push vs. Technology Pull?
  - New Models for Funding and Incentivizing RD&D?
- **How to Incentivize Private Innovation**
  - Cap-and-Trade?
  - Carbon Tax or Equivalents?
  - Other Options (Fee-Based Environmental Security Accounts)?
  - How Best to Protect the Economy?
- **How to Form a New International Framework?**
  - Major Economies Process?
  - Clean Energy Technology Fund for Emerging Economies?
  - Concessions on Tariffs on Environmental Goods & Services?
  - Post-Kyoto Framework in December 2009?

March 14, 2008

World Oil Prices and Government R&D



Runci and Dooley, "Energy R&D Investments: Past and Future (2007)

Path Forward

- A Visionary Long-Term Approach, Aimed at the UNFCCC Goal
- Continued U.S. Leadership on Tech. Solutions & Int'l Dialogue
- Near-Term Actions – Voluntary, Financial Incentives & Mandates
- 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 Transformational Change
  - Enable Broadened Consensus on Policy Formulation
- Expand Opportunities for S&T Cooperation Among:
  - Business, Industry, States and NGOs
  - Research Institutions and Academia
  - Cooperative Frameworks with S&T Actions Abroad
- Multi-Lateral Collaboration on Goals, Finance & Trade on Clean Energy
- Build a Bridge to Low-Emissions Future with Broadened Public Support
- Make Progress Toward Attainment of Multi-Goal Convergence

Back-Up

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.**

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

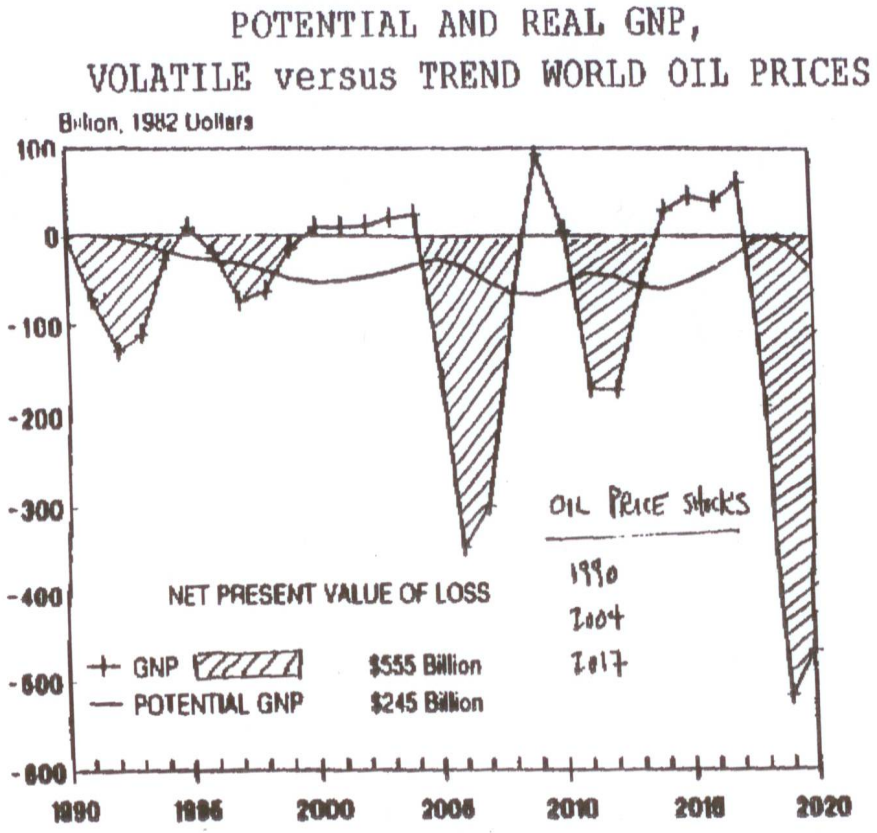
How Big is a Gigaton? Using U.S. Technology,* These Actions Can Cut Emissions by 1 GtC/Year

Today's Technology	Actions that Provide 1 Gigaton / Year of Mitigation
Coal-Fired Power Plants	Build 1,200 "zero-emission" 500-MW coal-fired power plants (in lieu of coal-fired plants without CO_2 capture and storage) (73% CF)
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) (90% CF)
Electricity from Landfill Gas Projects	Install 28,000 "typical" landfill gas electricity projects (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 (assume 12,000 miles per year per car)
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 (10% cell DC eff'cy; 1700 kWh/m2 solar radiance; 90% DC-AC conv. eff'cy).
Biomass fuels from plantations	Convert to biomass crop production a barren area about 20 times the total land area of Iowa (about 700 million acres)
CO_2 Storage in New Forest.	Convert to new forest a barren area about 9 times the total land area of the State of Washington (nearly 400 million acres) (Assumes Douglas Fir on Pacific Coast)

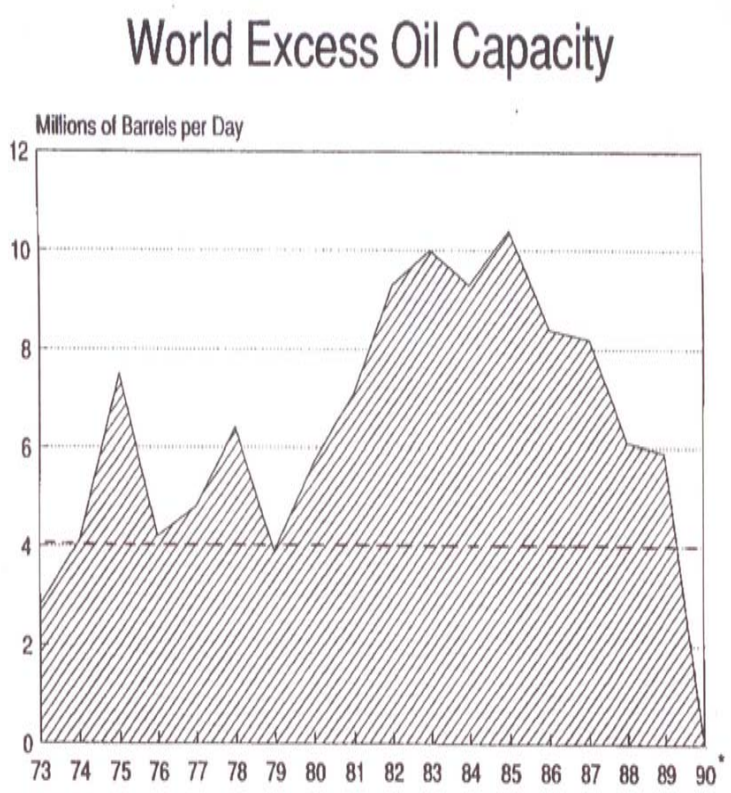
Giga-Tonne = Billion (10^{9}) Metric-Tonnes (1000 Kilograms)

*** Based on U.S. Data and Current Technology**

Energy Security Metrics



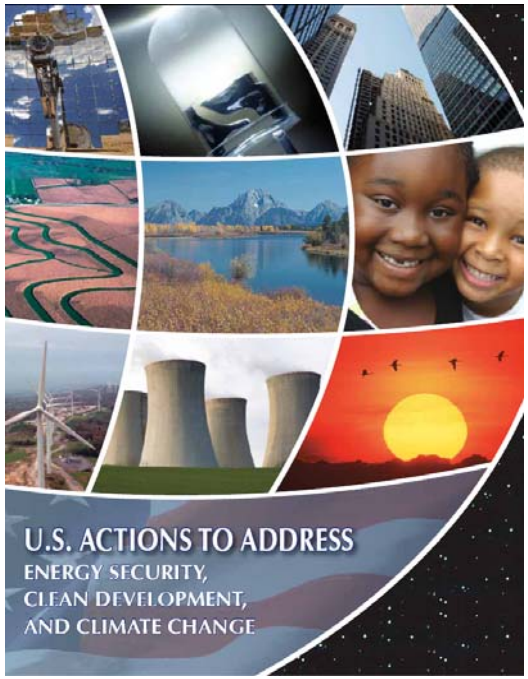
Source: Energy Information Administration



EIA, International Energy Outlook
*Post-July Capacity Data

Near-Term Policies and Measures

- **Voluntary Programs**
  - Climate Leaders
  - Climate VISION
  - Energy Star and Natural Gas Star
  - 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
  - Farm Bill Conservation*
  - Tropical Forest Conservation Act
- **Mandates (EISA 2007)**
- **Executive Orders**
  - Strengthening Federal Government Environmental, Energy, and Transportation Management
- **State Programs**



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

* Biological sequestration (forests), $1.6B for energy innovation, and $2B in loans for advanced biofuel plants

Financial Incentives

Existing Tax Incentives

- **Efficiency & Transportation**
  - Hybrid and Fuel Cell Vehicles (Tax Credit)
  - Clean Fuel Cars, Truck and Refueling Stations
  - Tax Credits for Energy Efficient Building Improvements (Residential and Commercial)
  - Tax Credits for Construction of Energy Efficient Homes
  - Exclusion of Utility Conservation Subsidies
- **Renewable Energy**
  - Renewable Energy Production Credits
  - Residential Solar Energy (Tax Credits)
  - Investment Tax Credits for Solar, Geothermal
  - Hydroelectric, Biomass Elec. (Excl. of Interest on Bonds)
  - Biomass Ethanol (Exemption from Excise Taxes)
- **Low-Carbon Fossil**
  - Coal Bed Methane (Production Credit)
- **Other and Crosscutting**
  - Industry Tax Credits for Landfill Gas and Combined Heat and Power

New Tax Incentives*

- **Efficiency & Transportation**
  - Conservation and Energy Efficiency
  - Tax Credit for Efficient Vehicles
- **Renewable Energy**
  - Extend Renewable Electricity Production Credit (e.g., Home Solar)
  - Renewable Energy Bonds
  - Renewable Content in Gasoline (e.g., Ethanol)
- **Low-Carbon Fossil**
  - Clean Coal Investment Tax Credit
- **Nuclear**
  - Production Credit for Advanced Nuclear,
  - Nuclear Decommissioning,
  - Risk Insurance
- **Other and Crosscutting**
  - Energy Infrastructure (Transmission)
  - Loan Guarantees for Power and Fuels

*EPAct05, EISA07, & Omnibus FY08 Appropriation

Recent Mandates

- **Mandatory Renewable Fuel Standard (RFS)**
  - Requires fuel producers to use at least 36 billion gallons of biofuel by 2022.
- **Corporate Average Fuel Economy (CAFE)**
  - Increases the national fuel economy standard to 35 miles per gallon by 2020.
- **Appliance and Lighting Efficiency Standards**
  - Sets energy efficiency standards for light bulbs (phase-out of incandescent lights)
  - Sets standards for residential and commercial appliances (More than 40 appliances).
- **Energy Savings in Buildings and Industry**
  - Increases energy efficiency of residential, commercial, and Federal buildings
  - Increases energy efficiency of industrial equipment and processes
- **State Renewable Portfolio Standards (24 States)**

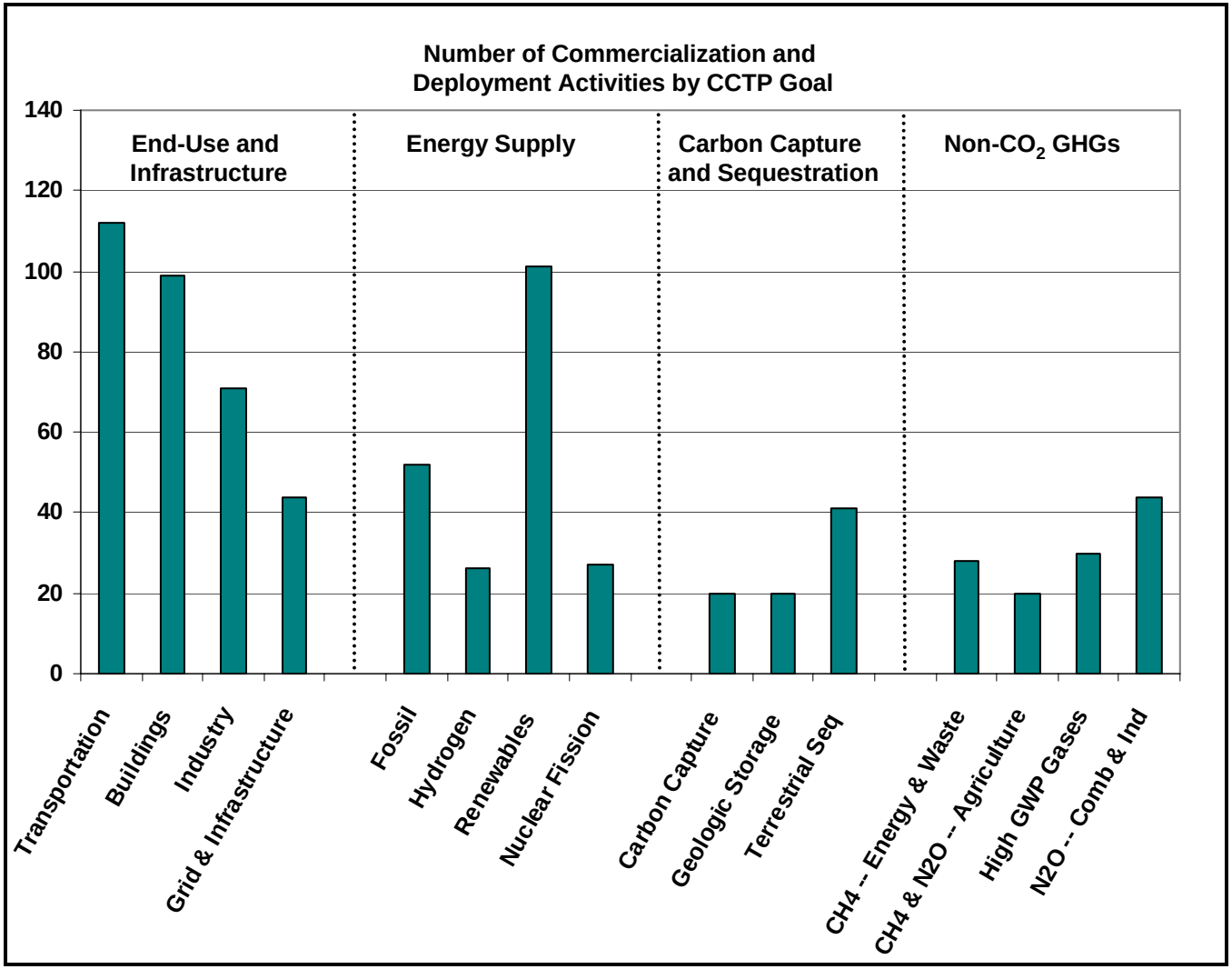
Barriers to Technology Deployment

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

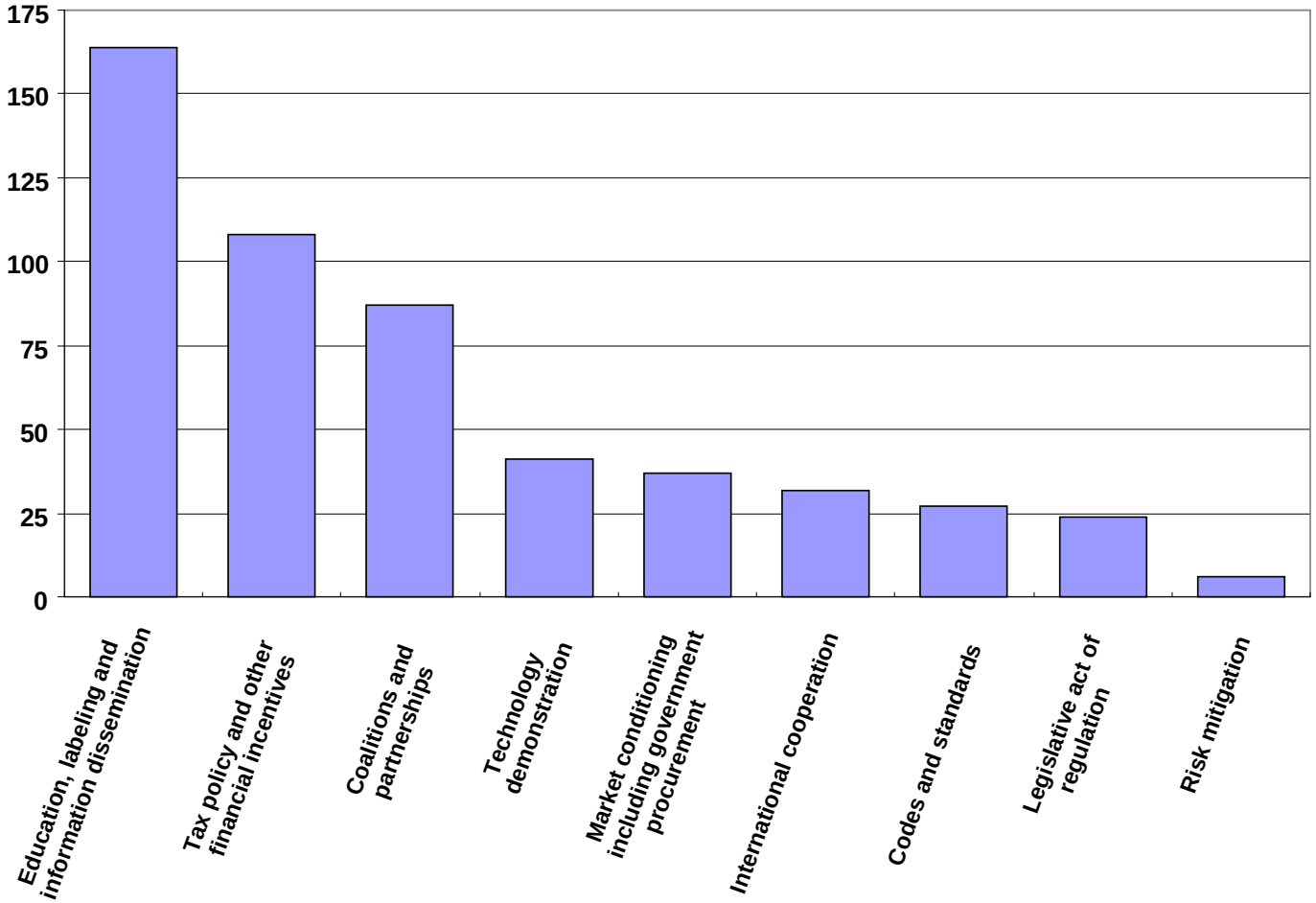
Barriers are organized into six categories consistent with EPAct 2005 Title XVI.

More Than 400 Policies & Measures to Address Barriers

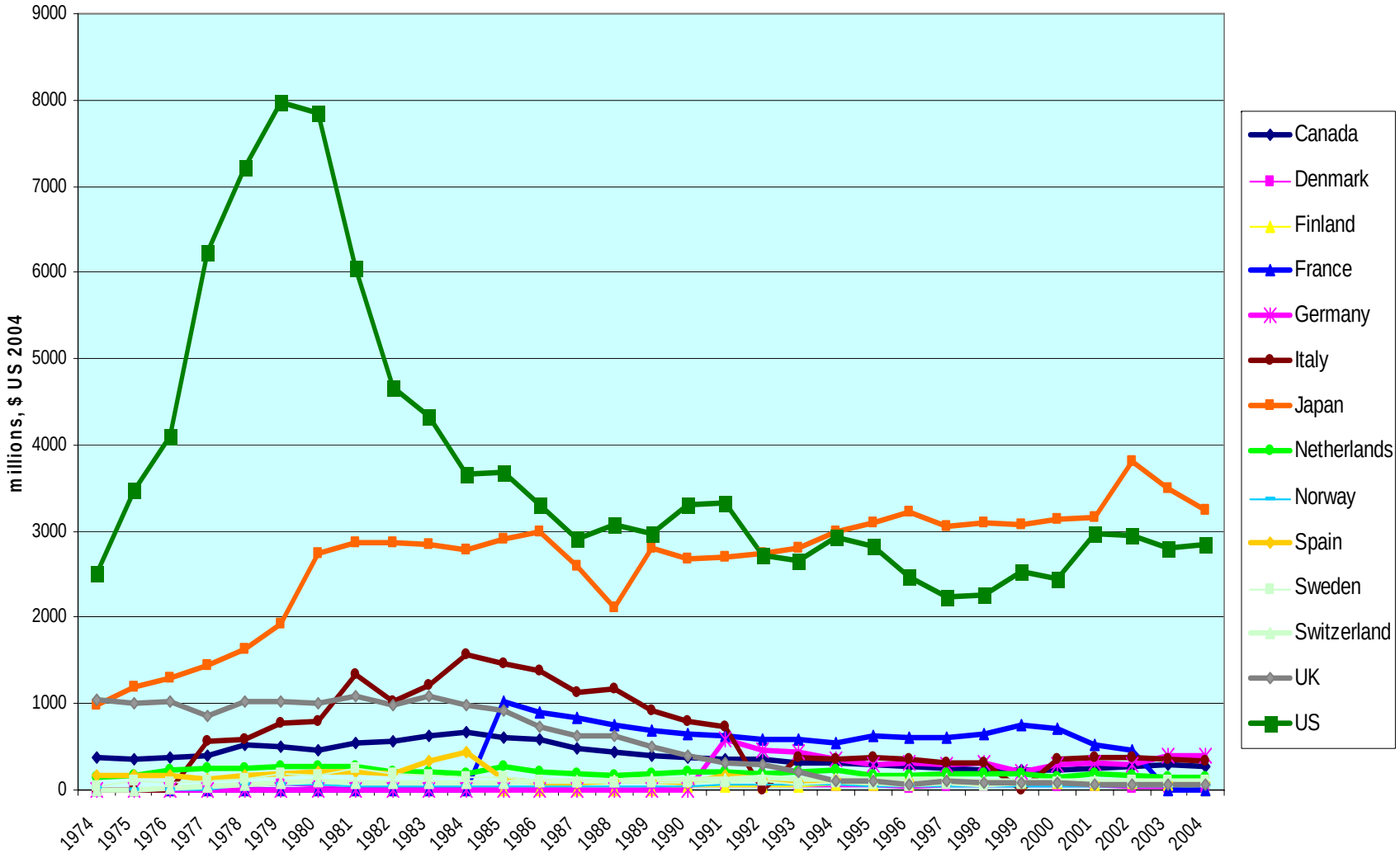


Commercialization & Deployment Policies & Measures, by Genre

Number of Government Commercialization and Deployment Activities by Type of Policy and Measure



History of Int'l Energy R&D



Runci and Dooley: "Energy R&D Investments: Past and Future" (2007)

International Framework For Addressing Climate Change

Global Action Programs

- Asia-Pacific Partnership (7 Nations)
  - Accounts for 50% of emissions
  - Nearly 100 actions
- G-8 Dialogue (13-20 Nations)
  - More than 40 programs
- Methane to Markets (20 Nations)
  - 180+ million tons reduced by 2015
- Renewable Energy and Efficiency (17 Nations)
- 12+ Bilateral Agreements on Technology and Lower Emissions
- Tropical Forest Conservation
- Stopping Illegal Logging
- Major Economies Process (17 Nations, Including EU)

Technology Advancement

- Carbon Capture and Storage (22 Nations)
- Future Gen Coal (5 Nations)
- Hydrogen (17 Nations)
- Global Nuclear Energy Partnership (19 Nations)
- Gen IV Nuclear (10 Nations)
- Fusion Energy - ITER (7 Nations)
- Global Earth Observation (71 Nations)
  - Recommended by National Academy of Sciences
- Clean Energy Technology Fund (US, UK and Japan, World Bank)

Major Economies Process

- The U.S. is working with other "Major Economies" to establish a new post-2012 framework on GHG emissions.
- Endorsed by UN, G8 & APEC leaders
- New framework by Dec. 2008 will help lead to an international agreement by the end of 2009.
- Six elements:
  1. A **long-term global goal** for GHG reduction, consistent with economic development & energy security objectives;
  2. **National plans** that advance the long-term global goal and that set mid-term goals that are effective and measurable;
  3. Collaborative **technology development and deployment strategies for key sectors**, including lower carbon fossil power generation, transportation, land use, and near zero carbon energy (e.g., efficiency, nuclear, wind, and solar);
  4. Improved entity-level **measurement and accounting** systems;
  5. Support accelerated adoption of clean technologies by **innovative financing and lowering/eliminating tariffs** and non-tariff barriers; and
  6. Robust programs to address **adaptation, forestry, and technology access** for all UN member states.
- Treasury seeking $2 billion over 3 years for Clean Energy Technology Fund.
- Second meeting held in Hawaii January 30-31.
- Third meeting planned for April in France.

"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	UNFCCC*

*** Observer**