IEA Workshop on Energy Technology Roadmaps

Roadmaps From the U.S. Climate Change Technology Program Strategic Plan

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International Energy Agency
15 - 16 May 2008
Paris, France

Part I
U.S. Climate Change Technology Program

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

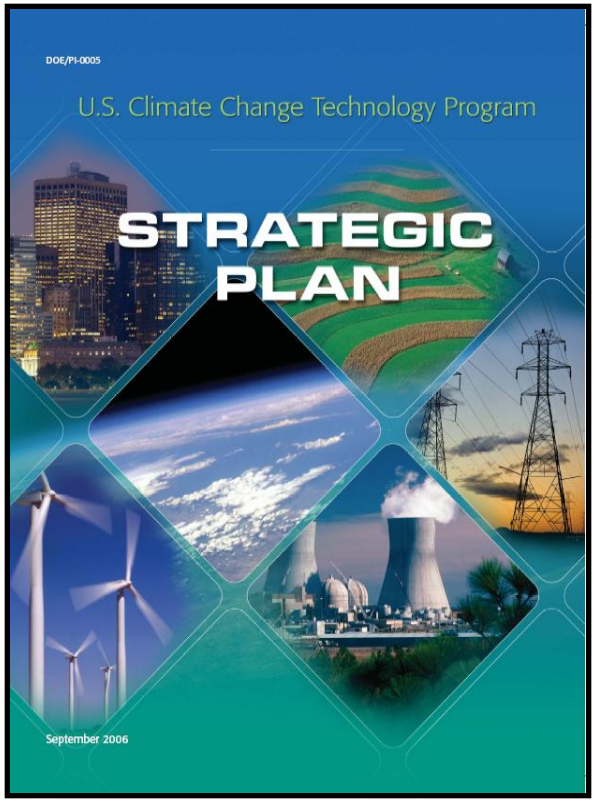
Via U.S. Climate Change Technology Program

- Strengthen Federal R&D Portfolio
- Prioritize Investments

Expand R&D Cooperation with non-Federal Entities

U.S. Climate Change Technology Program

- **U.S. Climate Change Technology Program**
  - Mission – Accelerate R&D on Adv. CC Techs
  - Scope – Ten Federal R&D Agencies
  - Budget -- $4.4 Billion Requested for FY'09
  - Activities – Coord. R&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.**



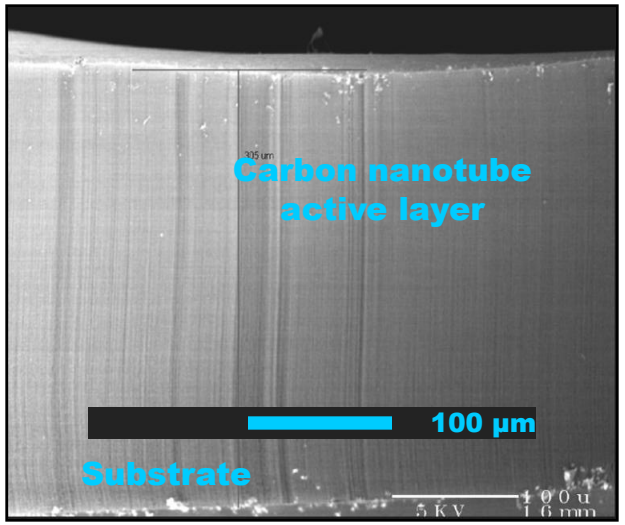
www.climatetechnology.gov

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)

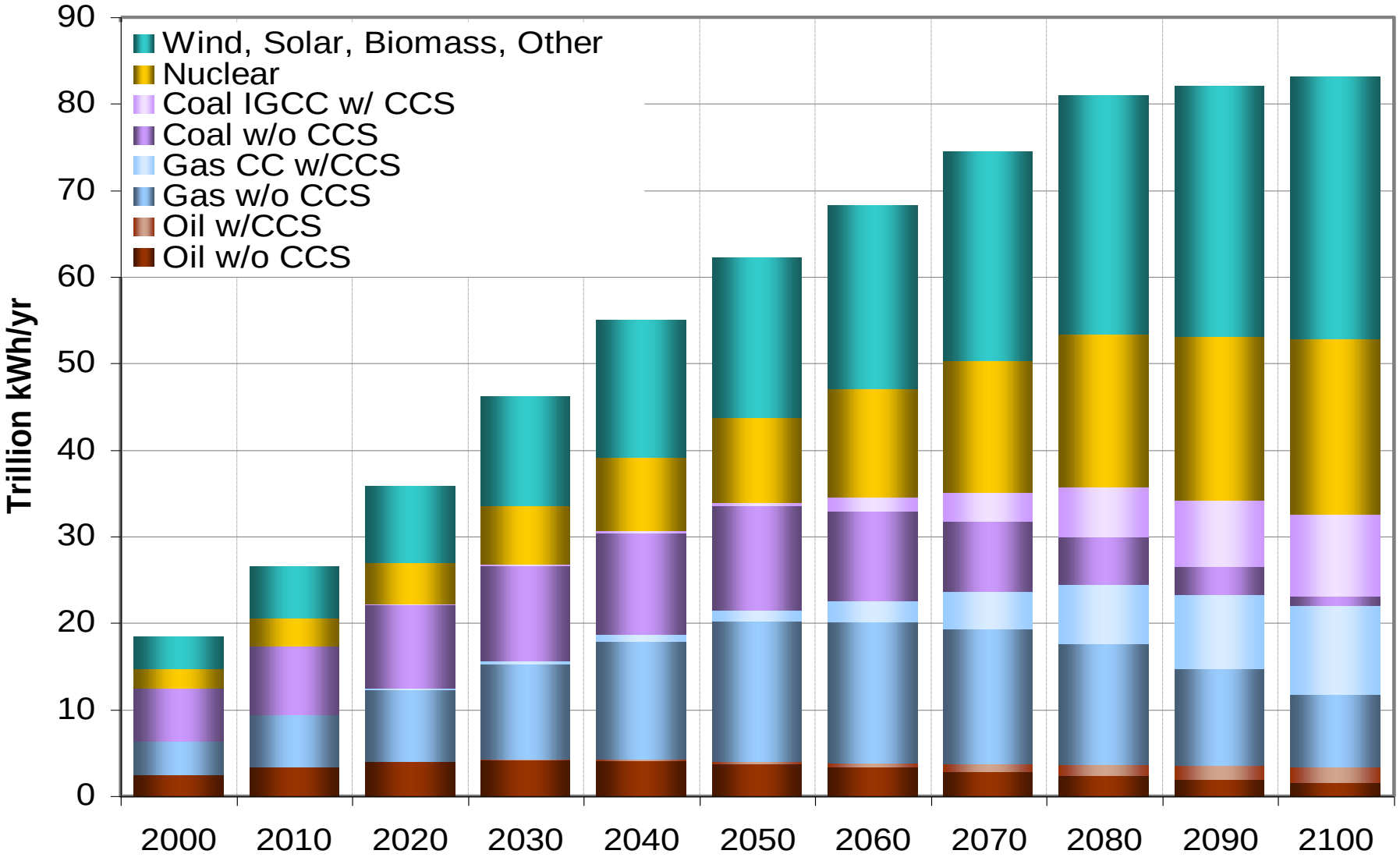
"De-Oil" Transportation

- **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



Technology Scenarios Explore the Future

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

Successful development of carbon capture and storage technologies for use in electricity, as well as in applications such as hydrogen and cement production.

Technology Scenario #2: "A New Energy Backbone"

Additional technological improvement and cost reduction for carbon-free energy sources, such as wind power, solar energy systems, and nuclear power.

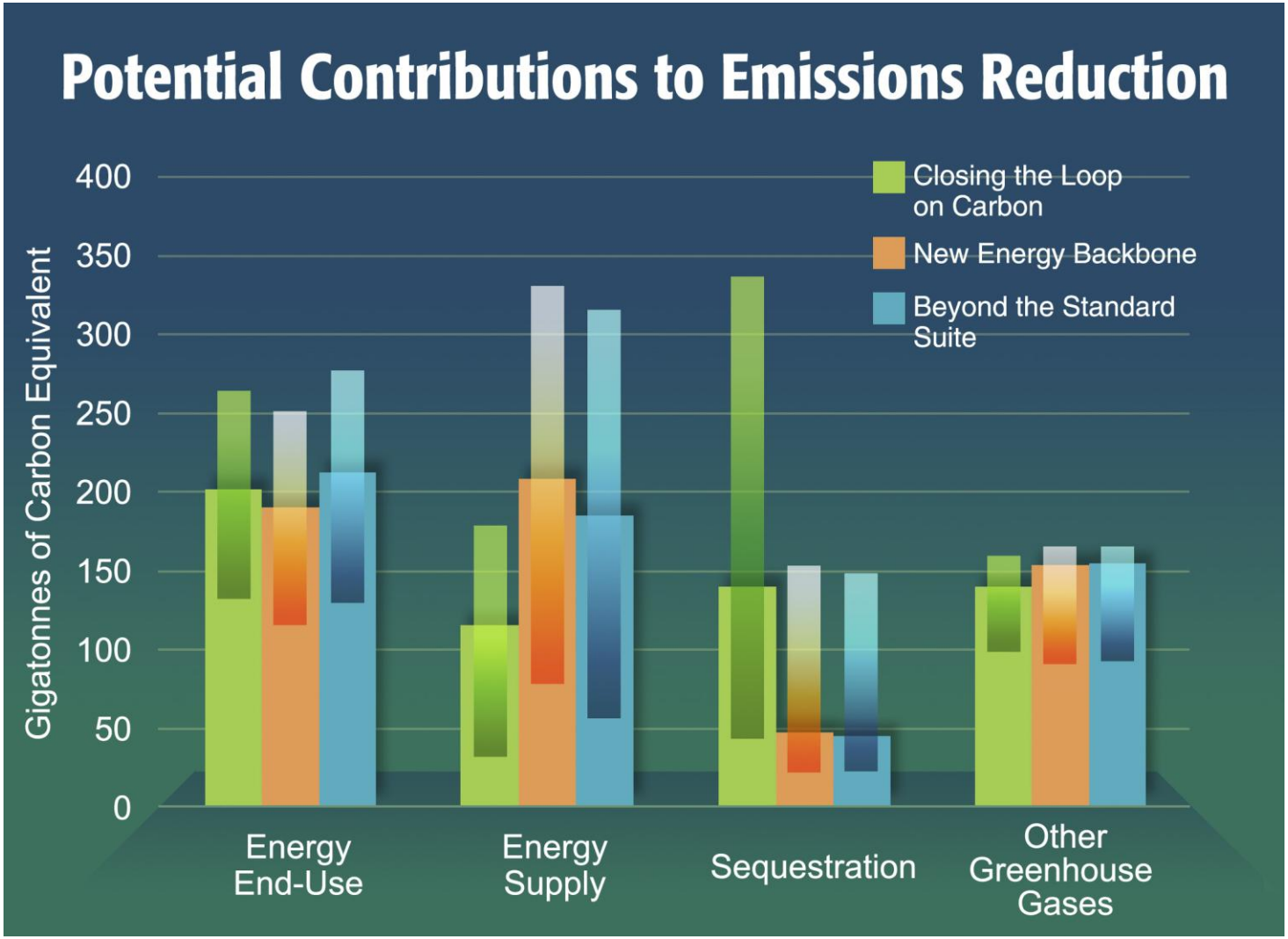
Technology Scenario #3: "Beyond the Standard Suite"

Major advances in fusion energy and/or novel energy applications for solar energy and biotechnology such that they can provide zero-carbon energy at competitive costs in the second half of this century.

Common Characteristics Across Scenarios:

- ✓ *Additional gains in energy efficiency beyond the reference case occur;*
- ✓ *Additional technologies for managing non-CO_2 GHGs become available;*
- ✓ *Terrestrial carbon sequestration increases;*
- ✓ *The full potential of conventional oil and gas is realized; and*
- ✓ *Hydrogen production technology advances.*

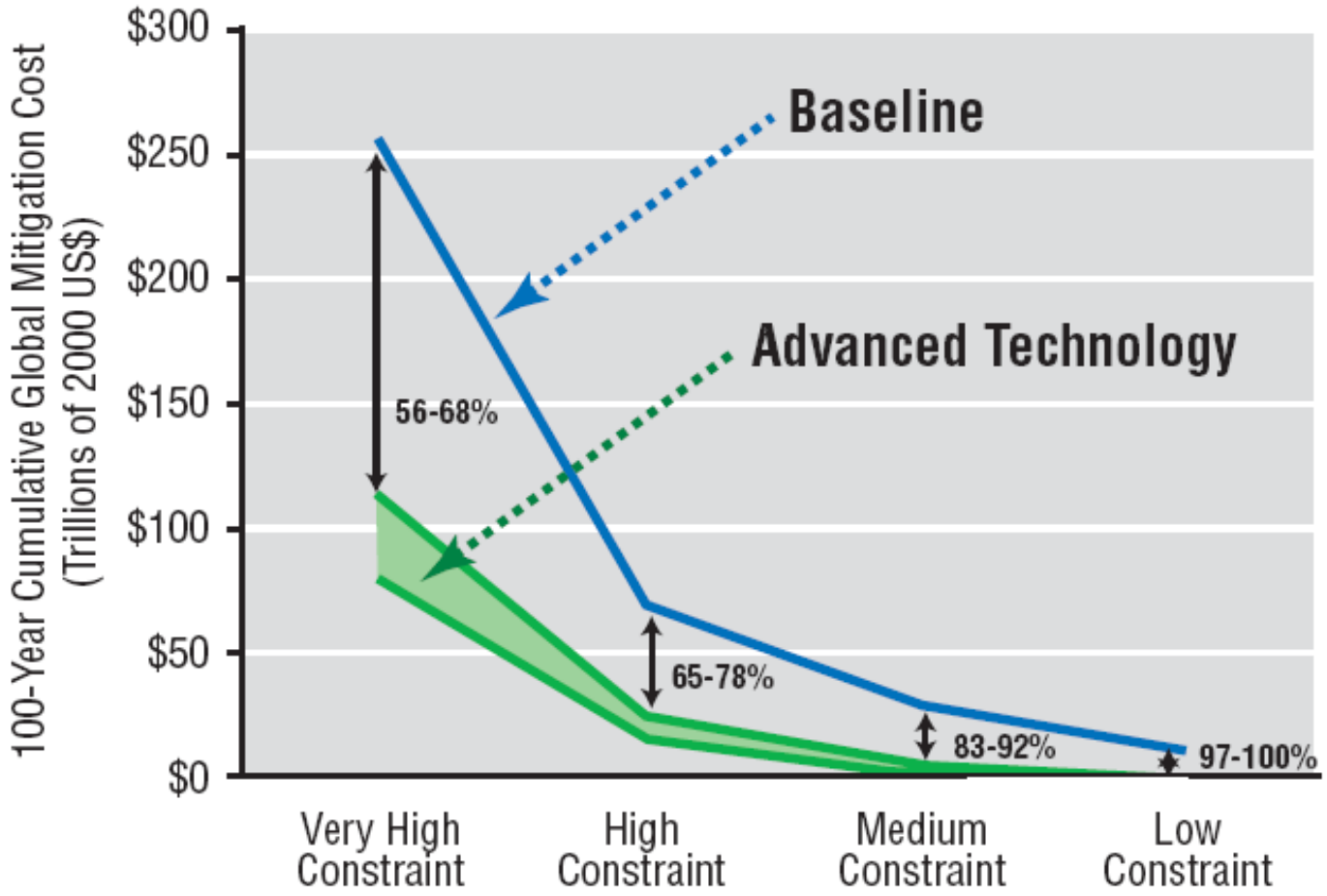
Results of An Integrated Assessment



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.

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**

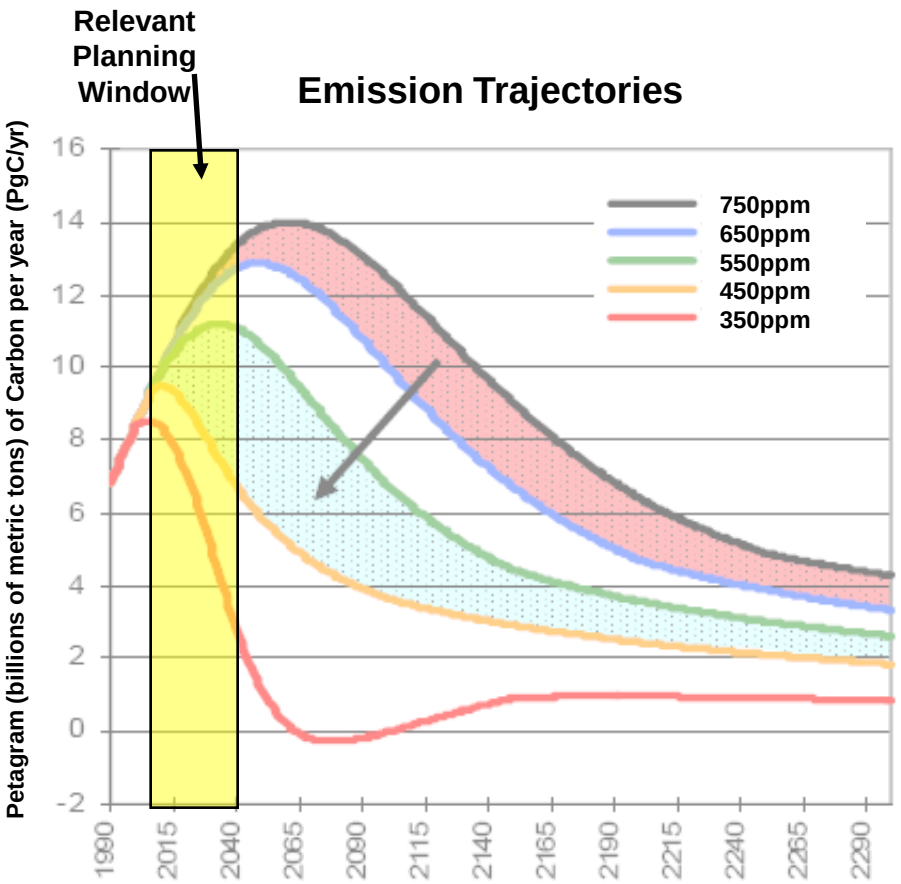
Timing is of the Essence

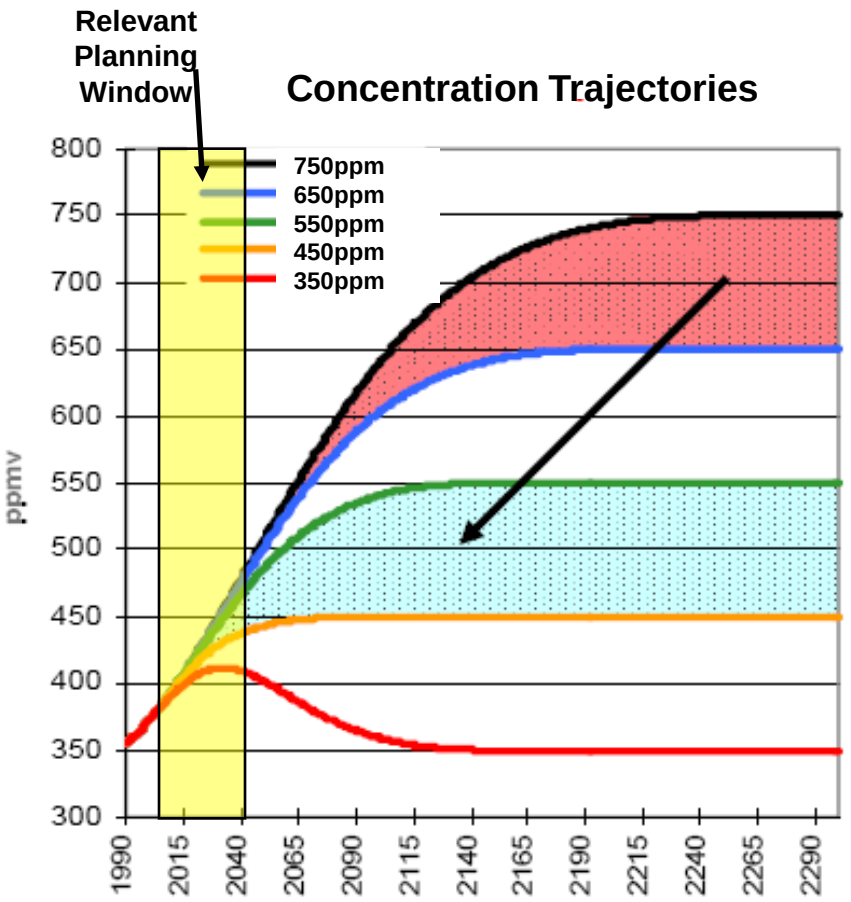
CCTP Strategic Goal	Very High Constraint	High Constraint	Medium Constraint	Low Constraint
Goal #1: Reduce Emissions from Energy End Use and Infrastructure	2010 - 2020	2030 - 2040	2030 - 2050	2040 - 2060
Goal #2: Reduce Emissions from Energy Supply	2020 - 2040	2040 - 2060	2050 - 2070	2060 – 2100
Goal #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.

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

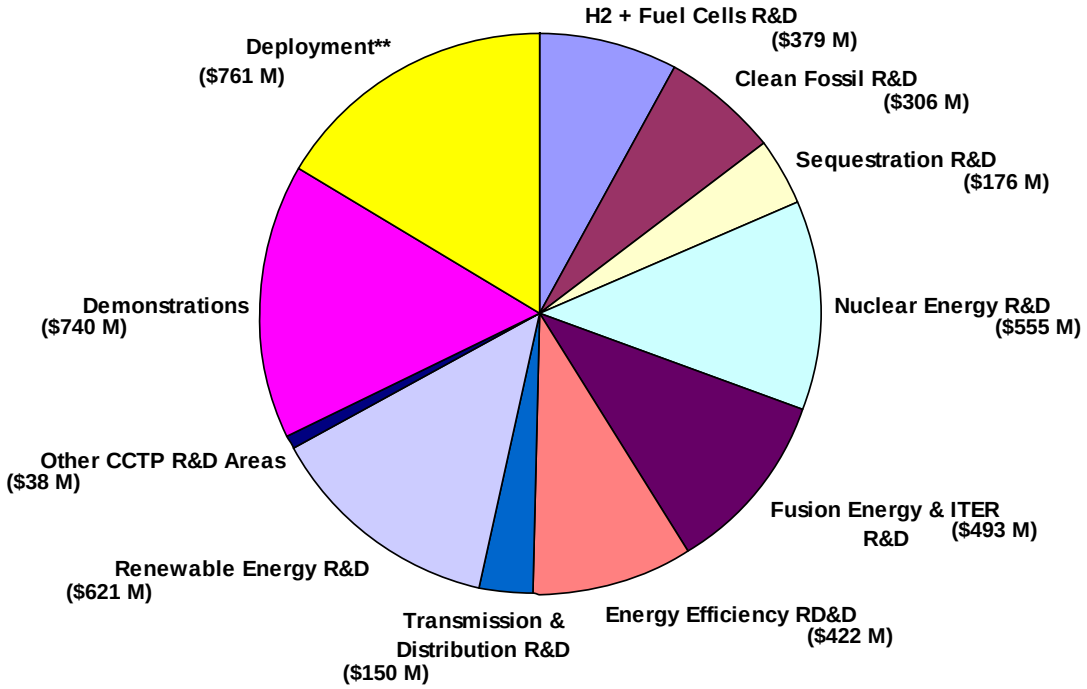
R&D

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				
							2020	2030	2040	2050	2100
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	N/A	N/A	TBD				
	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			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				

FY 2009 Budget Request -- CCTP Portfolio

CCTP FY09 Budget Request*
Portfolio of R&D, Demonstration and Deployment

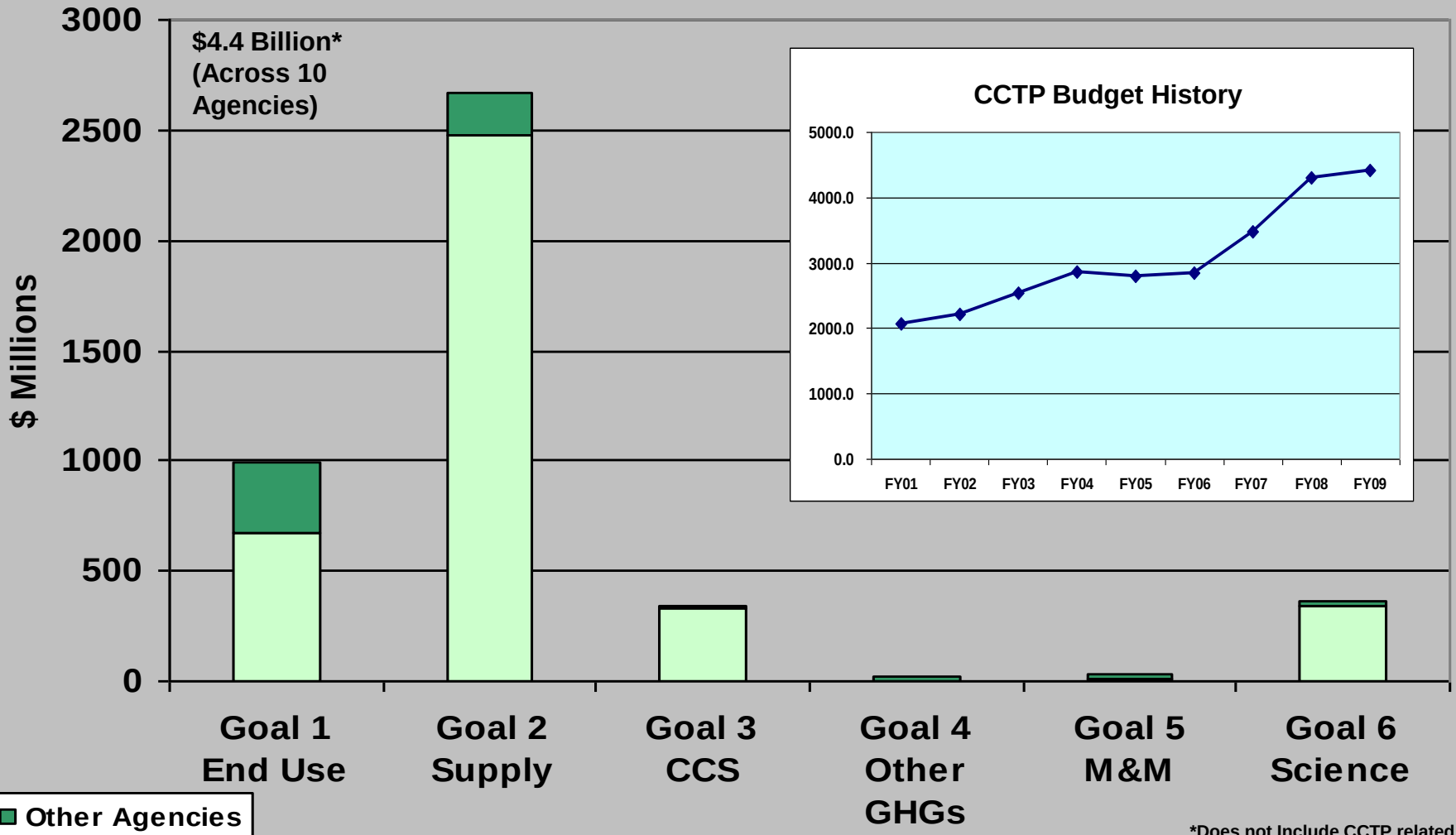
Total Multi-Agency FY09 Budget Request: $ 4,641 Million



* All CCTP Federal Agencies FY09 Budget Request (inc: USAID & STATE)

** Deployment is 70% Energy Efficiency

Federal Budget Request for FY 2009 – Good News for CCTP

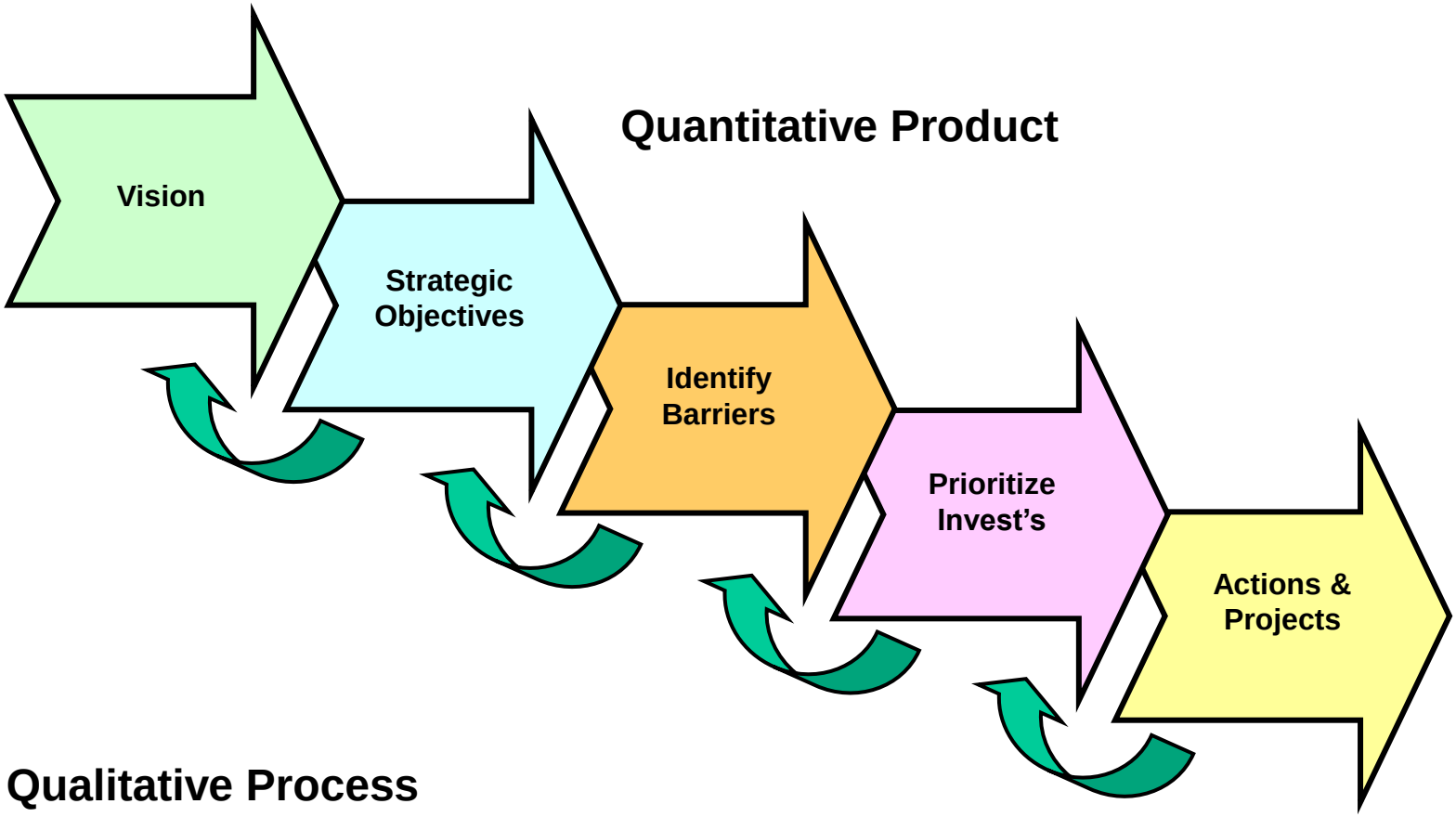


Strategic Goals, U.S. Climate Change Technology Program

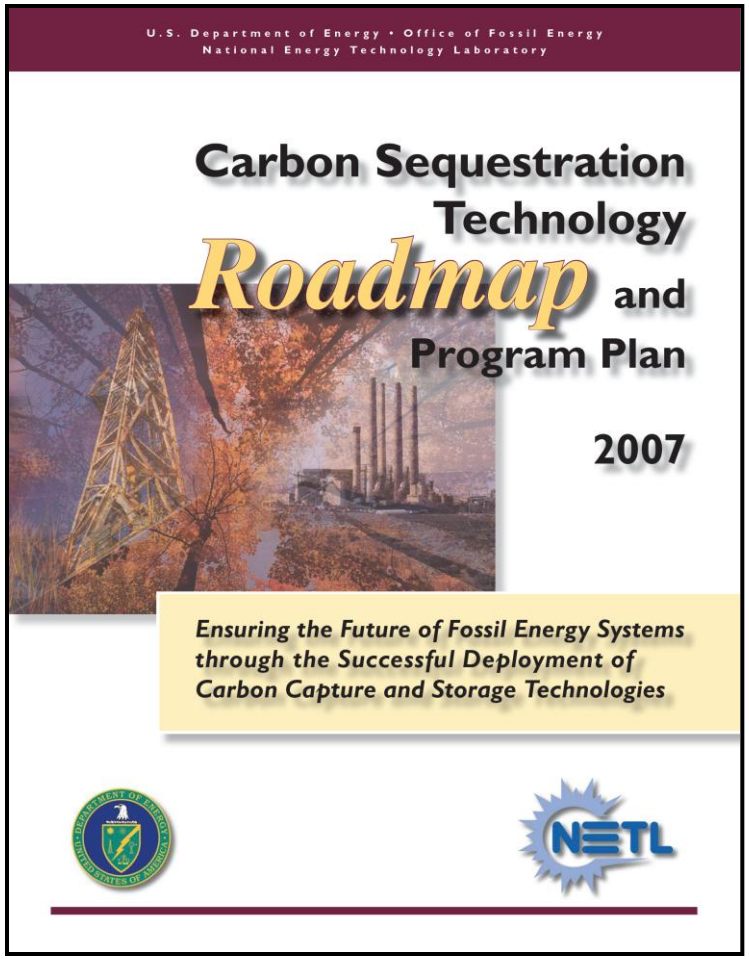
*Does not Include CCTP related Funding from STATE ($36M) and USAID deployment activities ($189M).

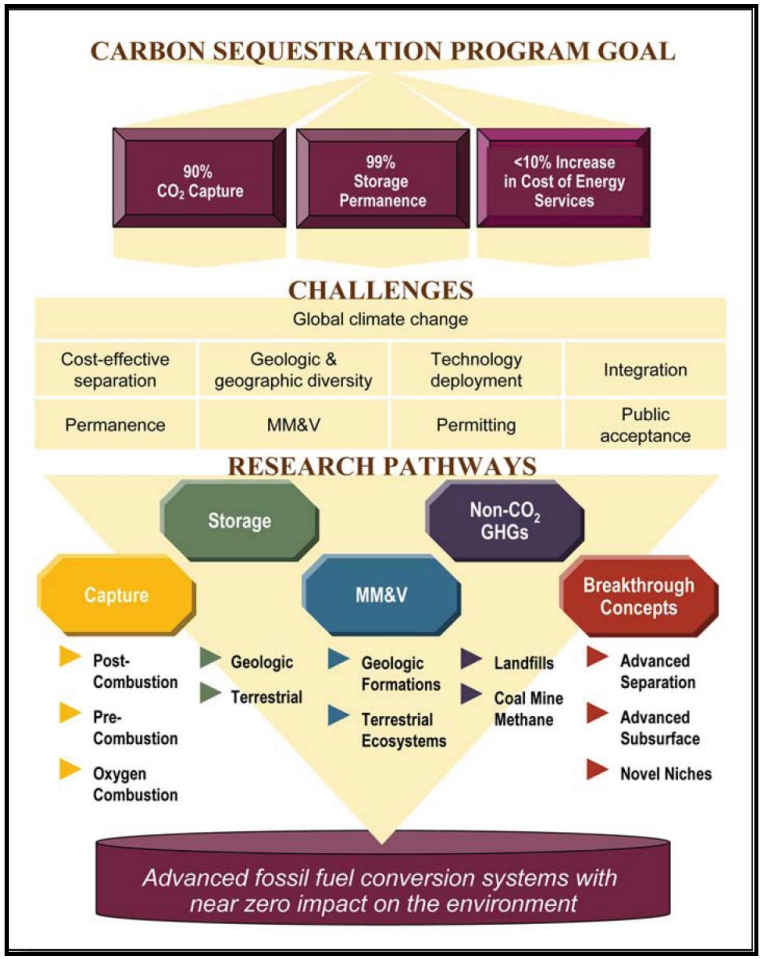
Part II
Examples of Roadmaps and Applications

Critical Elements of Successful Roadmaps

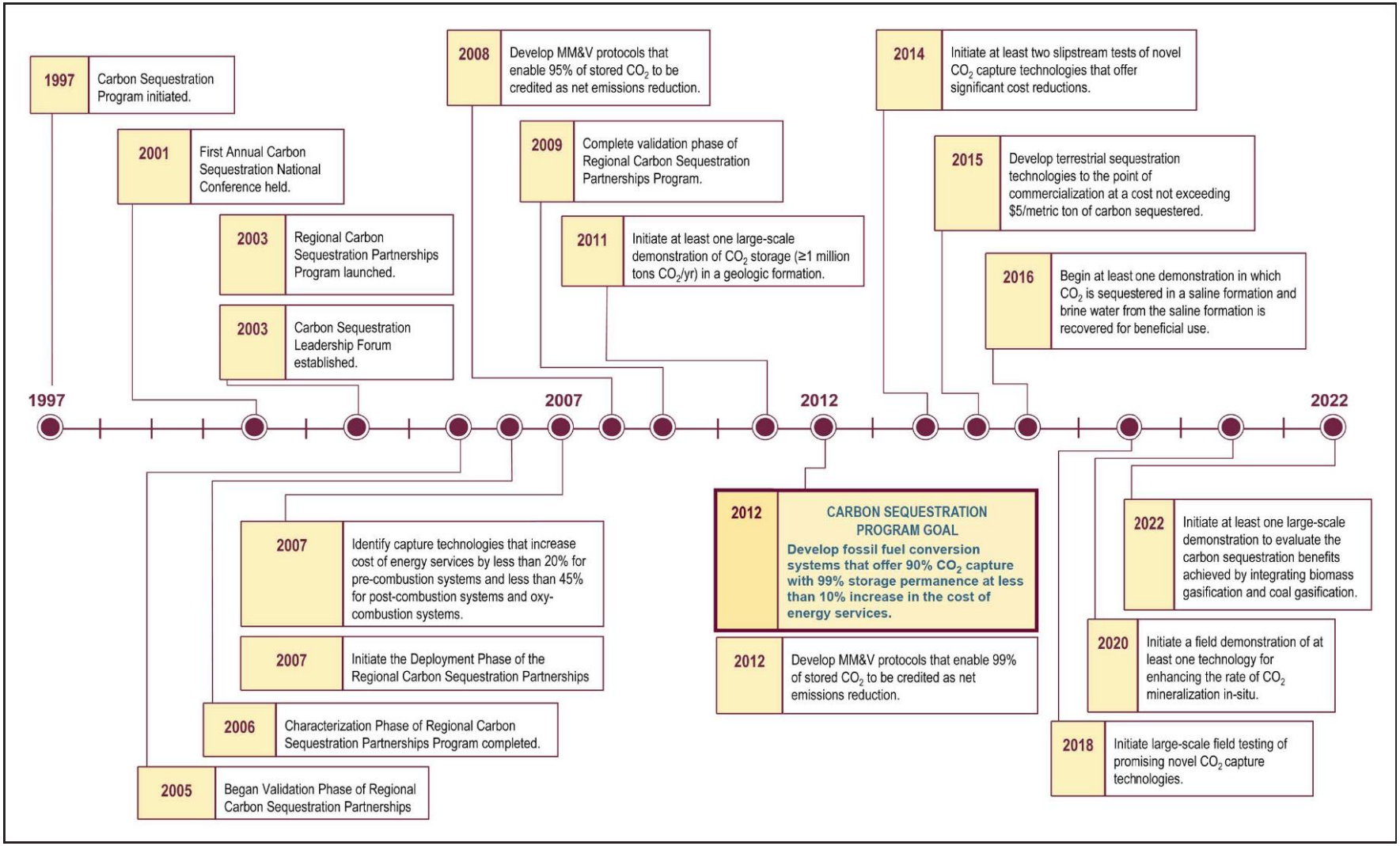


Carbon Sequestration Technology Roadmap





Carbon Sequestration Program Milestones and Goals

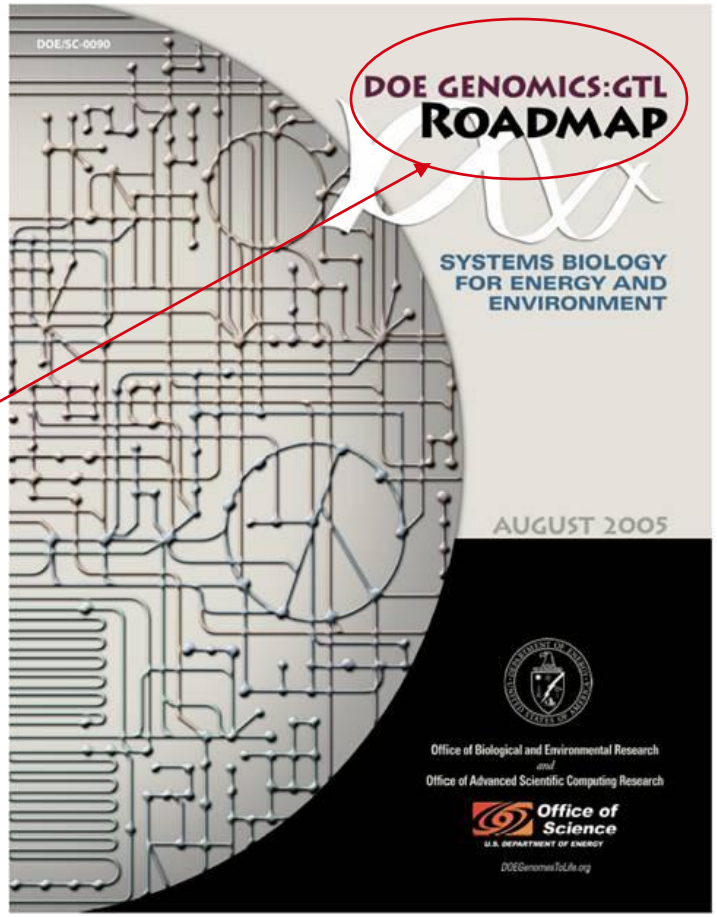


NETL, "Carbon Sequestration Technology and Program Plan," 2007

Basic Research Needs Roadmaps

Roadmaps from Basic Research Needs Workshops (2002 – 2007):

- Catalysis for Energy
- Electric Energy Storage
- Clean and Efficient Combustion of 21st Century Transportation Fuels
- Advanced Nuclear Energy Systems
- Solid-State Lighting
- Superconductivity
- Breaking the Biological Barriers to Cellulosic Ethanol
- Genomics: GTL Roadmap
- The Path to Sustainable Nuclear Energy
- Solar Energy Utilization
- Advanced Computational Materials Science: Application to Fusion and Generation IV Fission Reactors
- Nanoscience Research for Energy Needs
- Hydrogen Economy
- Assure a Secure Energy Future
- Opportunities for Catalysis



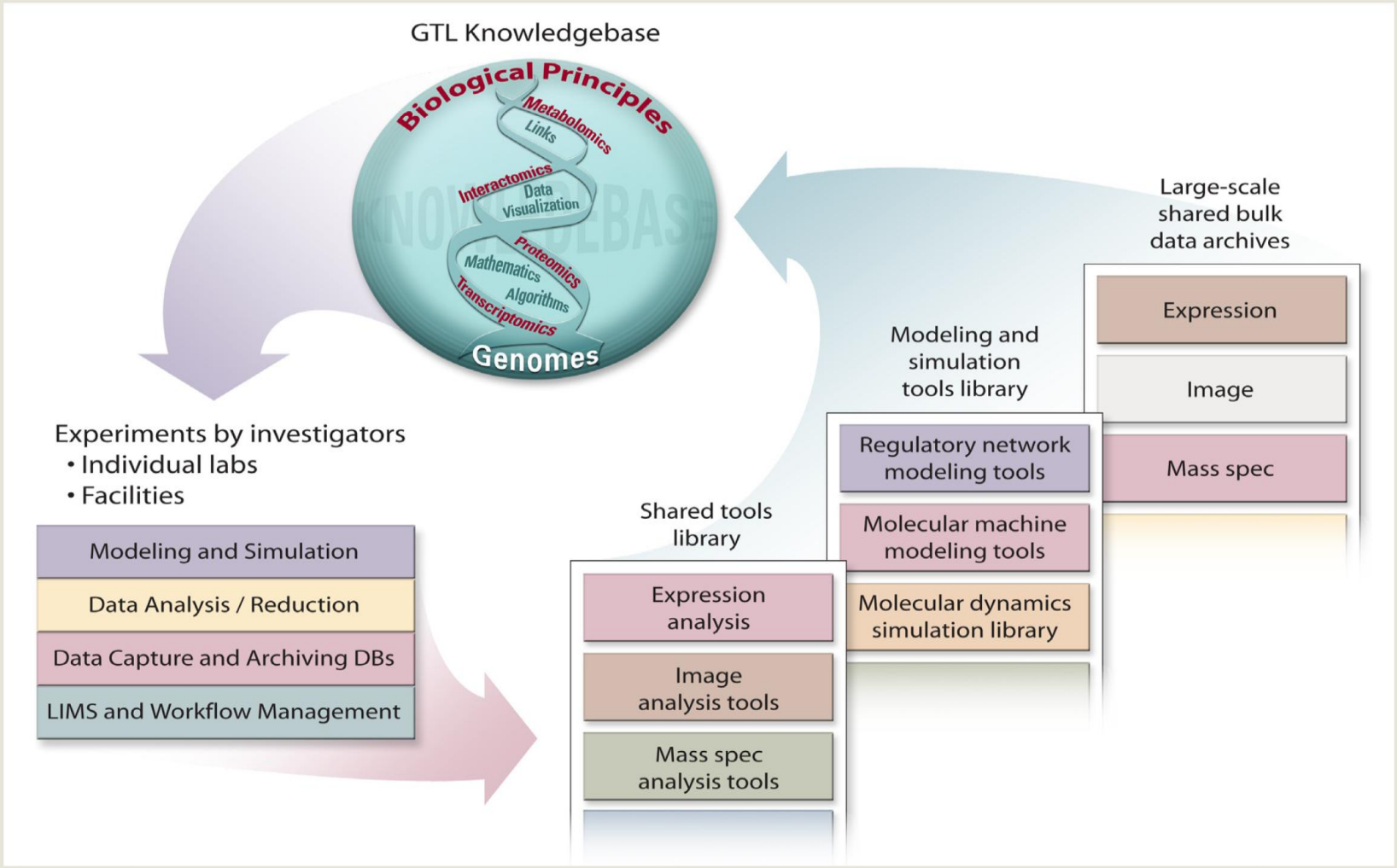


Fig. 1. GTL Integrated Computational Environment for Biology: Using and Experimentally Annotating GTL's Dynamic Knowledgebase. At the heart of this infrastructure is a dynamic, comprehensive knowledge-base with DNA sequence code as its foundation. Offering scientists access to an array of resources, it will assimilate a vast range of microbial data and knowledge as it is produced.

Part III

International Cooperation & Collaboration

Observations and Options

Level of Global R&D Investment -- Too Low?

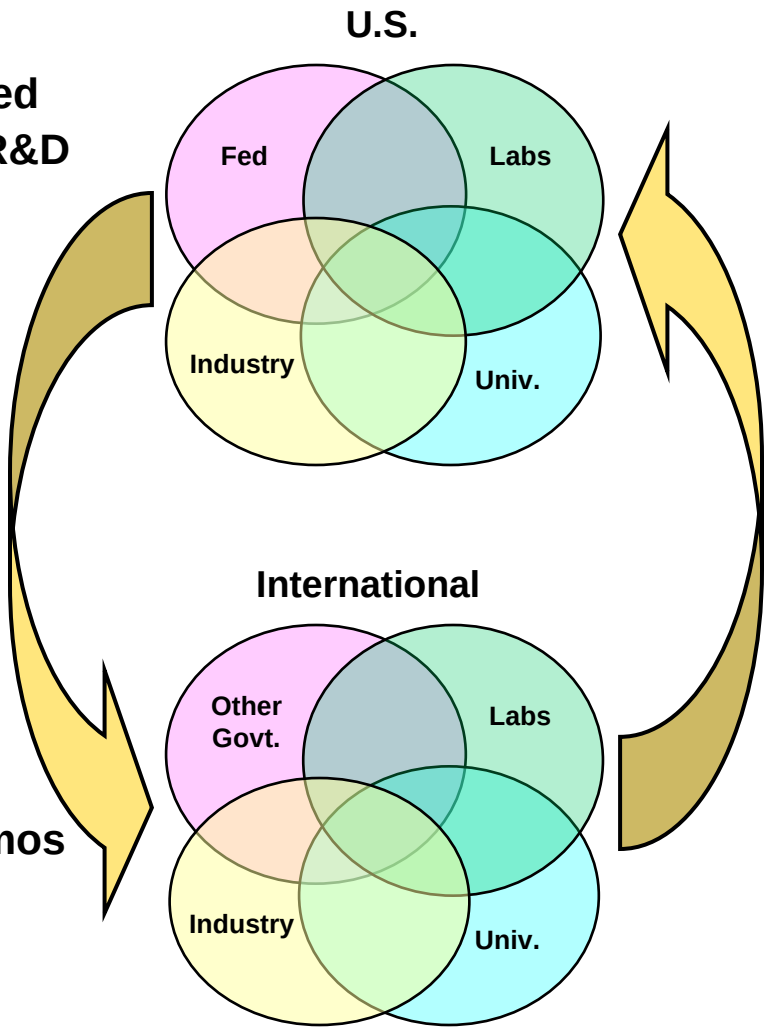
- Pace of Progress Too Slow ?
- U.S. Federal R&D is Increasing, but Constrained
- Two Countries Account for 80 Percent of CC R&D
- Other Governments' R&D Decreasing

How to Lift Global Effort?

- More U.S. R&D ?
- More International R&D ?
- More Private Sector R&D ?
- Technology Push vs. Technology Pull ?
- New Models for Incentivizing R&D ?

Potential Areas for Enhancement

- Coord., Integrated, Global R&D Strategy
- Better Access to Under-Utilized Assets
- More Int'l R&D Collaboration
- Division of Labor on Key Tech. Initiatives, Demos
- Enhanced S&T Cooperation
- Addressing Non-Technical Barriers
- Experimenting with New R&D Models



International Cooperation

Benefits

Raise Overall Global Level of Effort

Accelerate Technology Development

Pool Technical Resources

Gain Access to Privileged Facilities

Broaden Knowledge Base

Facilitate Exchange of Information

Enable Multi-Path Approaches

Harmonize Technical Standards

Reduce Partner Costs & Risks

Increase Likelihood of Success

Challenges

Diverse National R&D Funding Motivations, Schemes and Priorities

Lack of Common, Shared Vision

Heterogeneous Program Designs

Patents & Intellectual Property Issues

Other Barriers (e.g., National Security)

Administrative Complexity and Cost

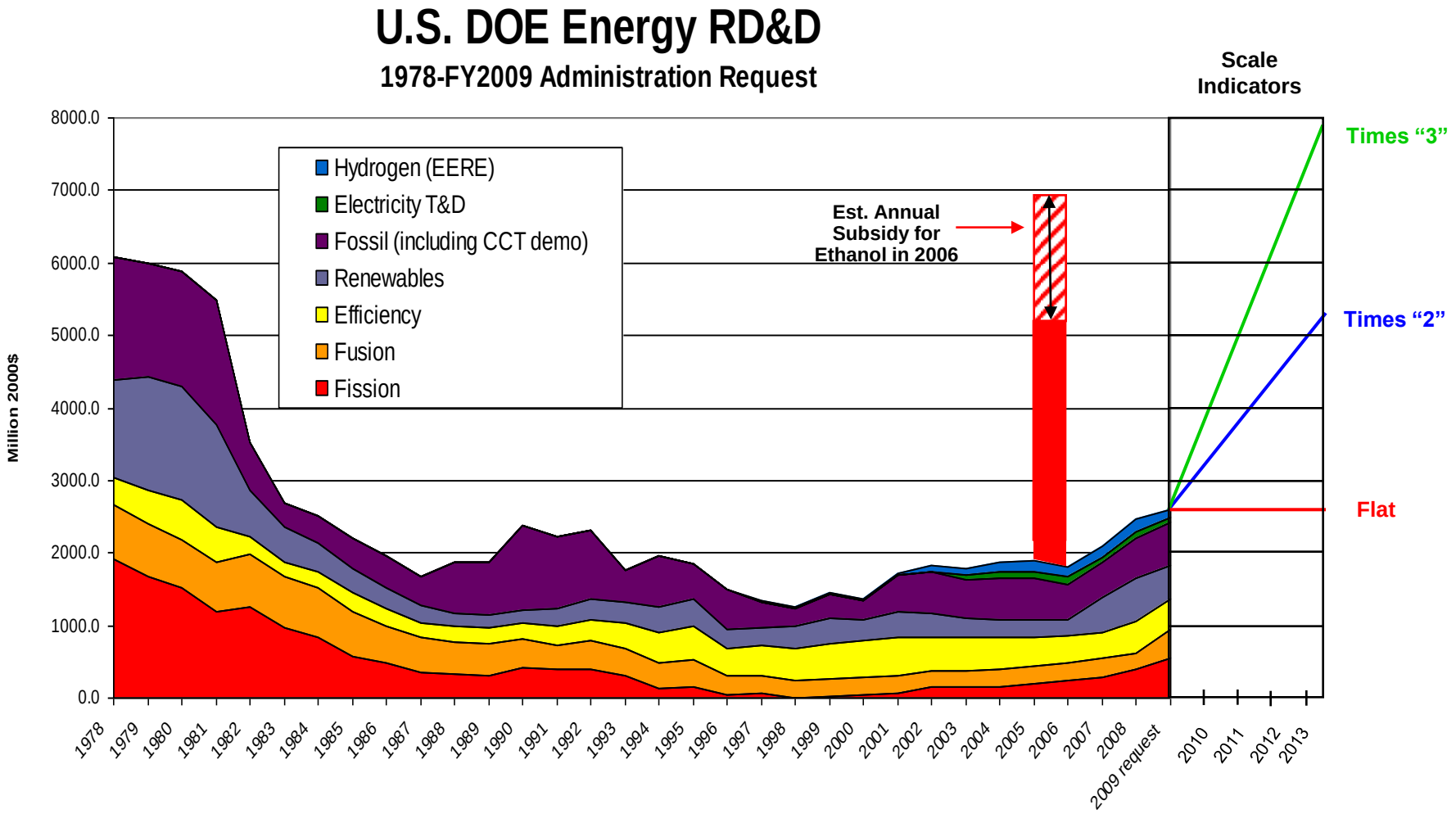
Travel and Coordination Costs

Management & Accountability Issues

Technical Support (e.g. IPCC/TSU)

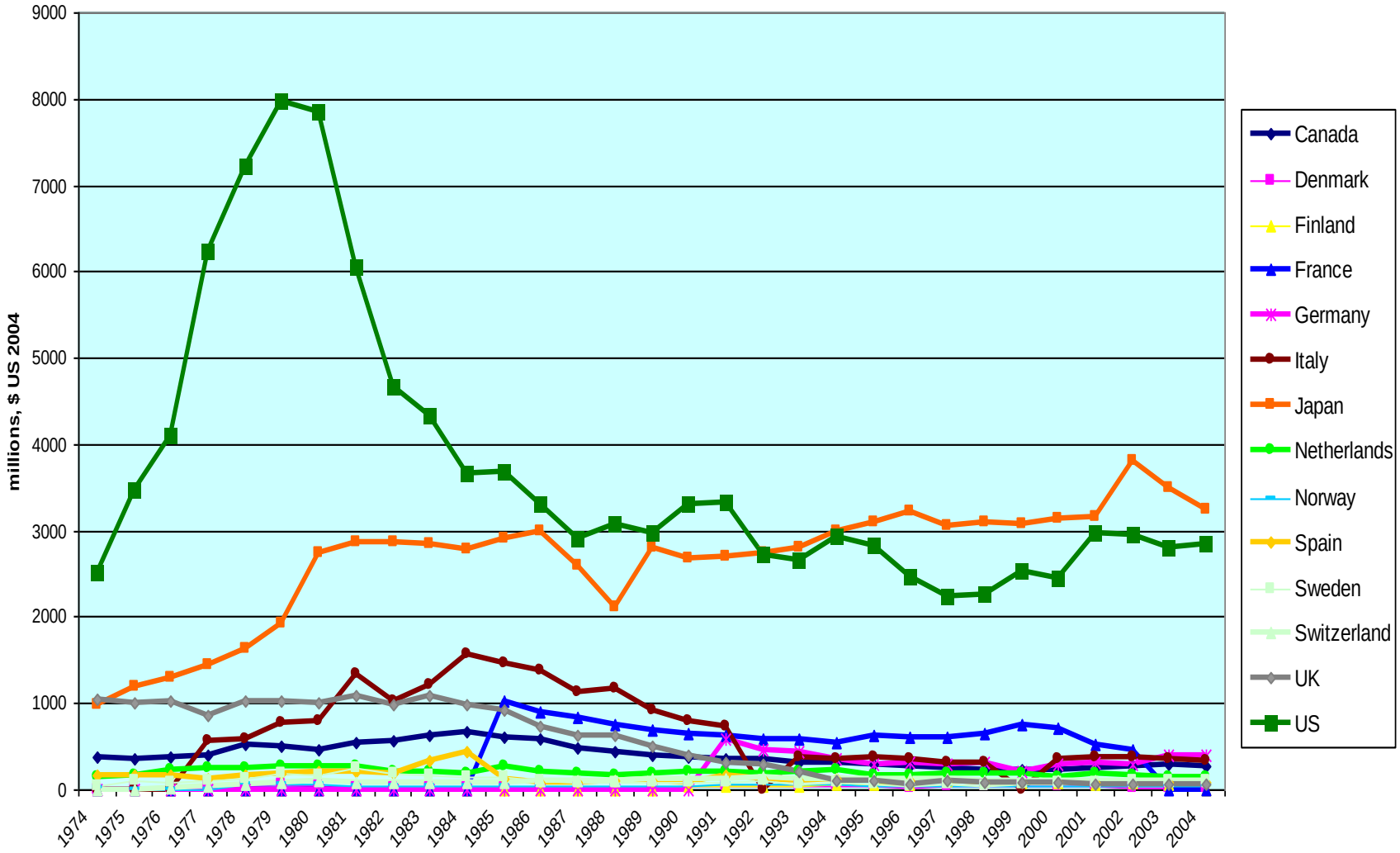
Need for Strong Central Leadership

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. File downloaded at: http://belfercenter.ksg.harvard.edu/publication/18152/doe_budget_authority_for_energy_research_development_and_demonstration_database.html

History of Int'l Energy R&D



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

Key Technologies & International Cooperation

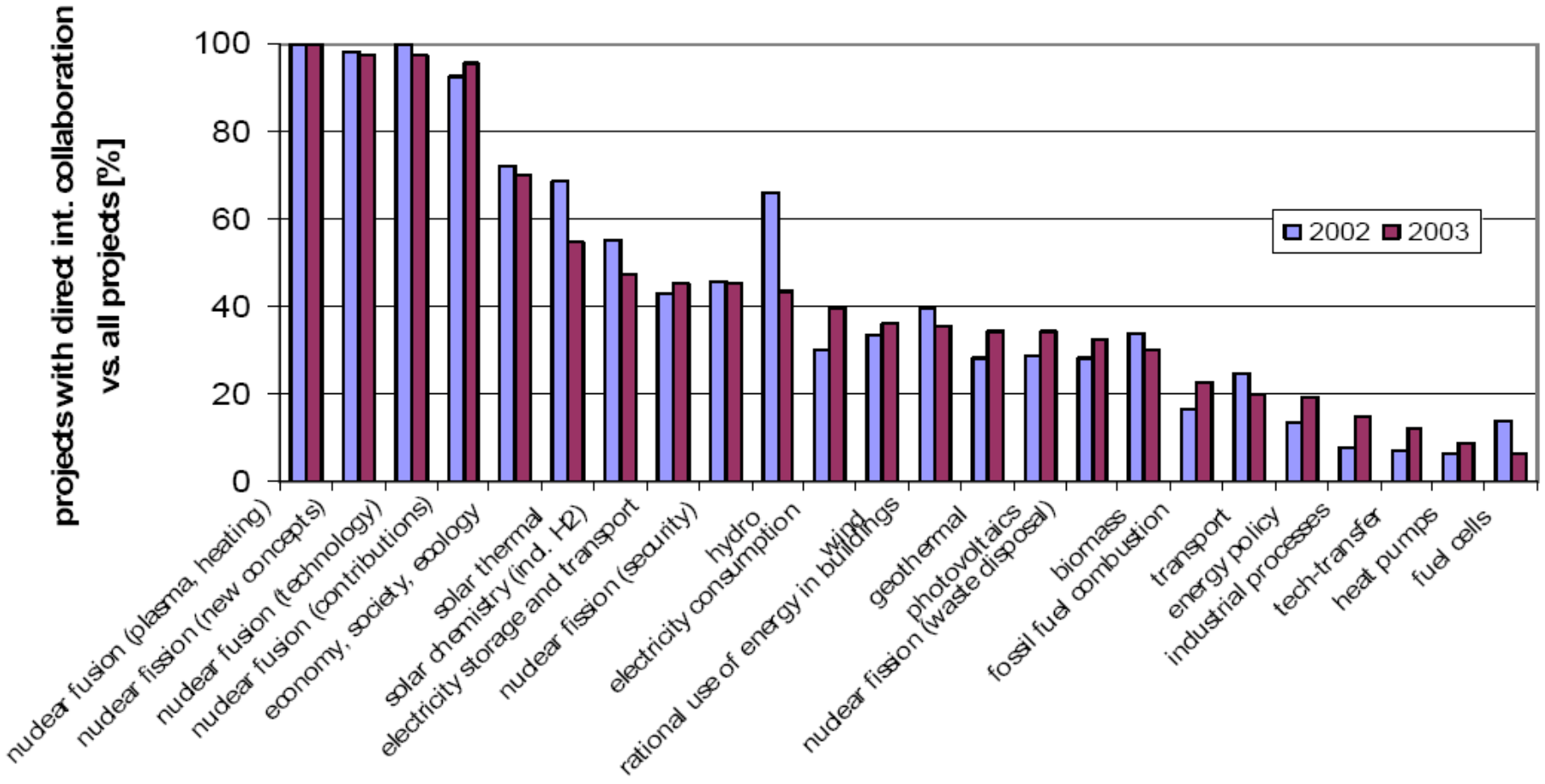
Key Technologies

- Advanced Lighting
- Building & Home Construction
- Advanced Transportation
- Grid (Power Electronics)
- Clean Coal
- Advanced IGCC
- Geothermal
- Hydro/Wind/Solar Power
- Rural/Village Energy Systems
- Bioenergy
- Civilian Nuclear Power
- Methane Capture/Use
- Agriculture/Forestry

International Cooperation

- 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
- Asia Pacific Partnership (6 Nations)

Experience with International Collaboration



CERT(2006)7; CERT Experts Group on R&D Priority Setting and Evaluation
Summary Report of Experts Group Meeting 2004 – 2005 (Rome, Paris, Lisbon, Vienna)
Visions – Strategies – Co-operation End of Term Report 2004/2005

Potential Areas for Int'l Collaboration

Energy End-Use Technologies	Energy Supply Technologies	Capture CO_2 Directly from Atmosphere
Zero-Emission Vehicle Systems	Stationary Fuel Cells	Geologic Storage: Safety, Health, and Environmental Risk Assessment
Multi-Modal Intercity & Freight Transport	Zero-Emission Fossil Energy	Geologic Storage: Large-Scale Demonstration
Engineered Urban Designs & Regional Planning	Hydrogen Zero-Emission Fossil Energy	Terrestrial Sequestration: Reforestation
Low Aviation Emissions	Low-Cost H_2 Storage & Delivery	Terrestrial Sequestration: Soils Conservation
Ultra-Efficient HVACR	Cost-Competitive Solar PV	Carbon & CO_2 Based Products & Materials
Intelligent Building Systems	Cellulosic Biofuels	Ocean CO_2 Biological Impacts Addressed
Energy Managed Communities	Photolytic Water Splitting	**Non CO_2 GHGs**
C&CO_2 Managed Industries	Advanced Fission Reactor and Fuel Cycle Technology	Precision Agriculture
Water and Energy System Optimization	Proliferation-Resistant Fuel Cycles	Zero-Emission Agriculture
Industrial Heat, Power, Processes	Advanced Concepts for Waste Reduction	Solid-State Refrigeration/AC Systems
High-Efficiency, All-Electric Manufacturing	Demonstration of Burning Plasmas	Catalytic Reduction of N_2O
Closed-Cycle Products & Materials	Fusion Power Plants	**M&M**
Energy Storage for Load Leveling	**CCS**	Fully Operational Sensor and Satellite Networks
Advanced Controls and Power Electronics	Post Combustion Capture	Low-Cost Sensors and Communications
Wireless Transmission	Oxygen Separation Technologies	MM Systems Architecture

Potential Role for IEA

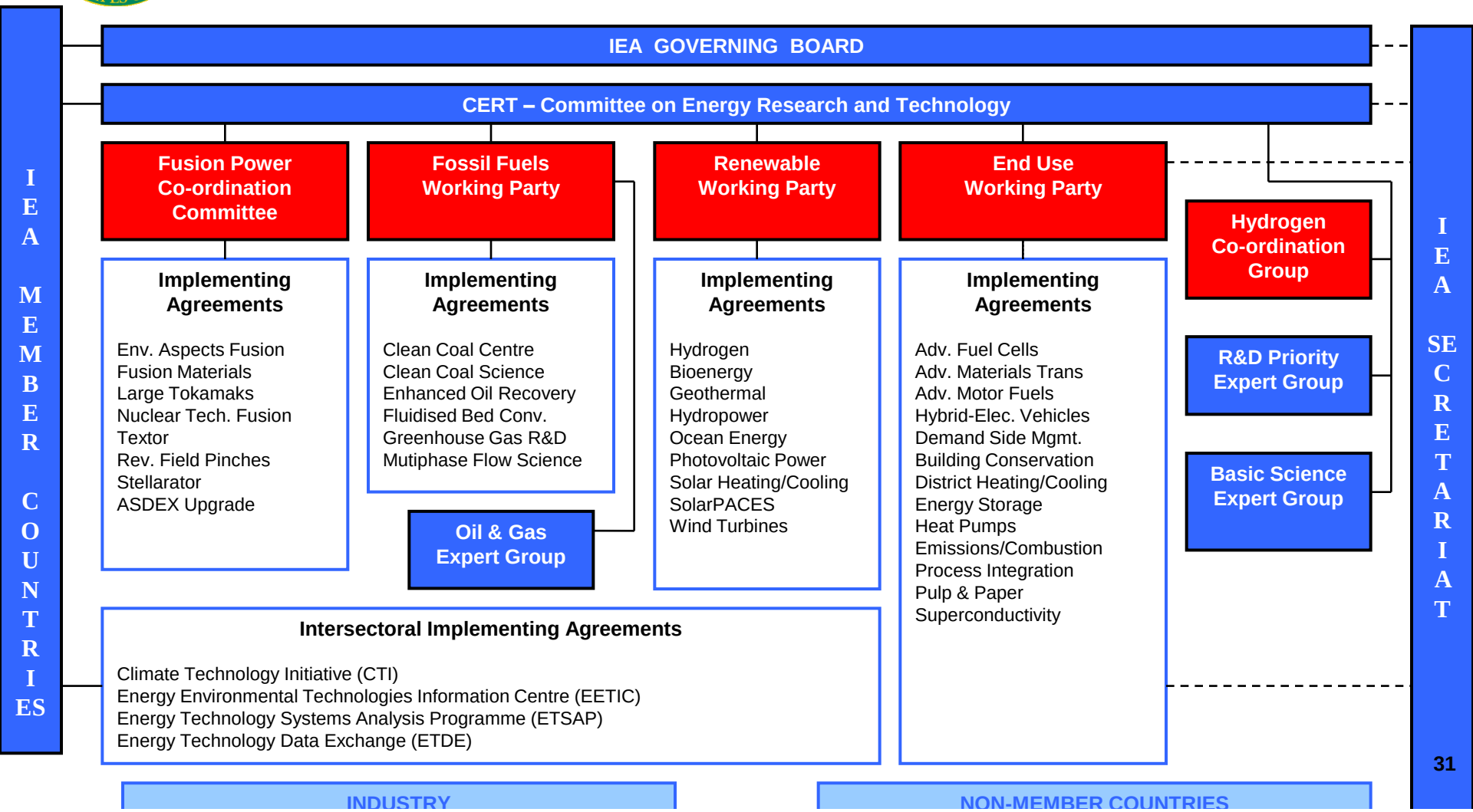
Advantages:

- ETP/Scenarios Provide Foundation for Long-Term Strategic Vision
- Decades of Experience in RTD Cooperation
- Flexible Infrastructure for Countries Seeking Cooperation
- Bottom-Up Approach Accommodates Diversity of Interests
- Institutional Setting Secures High Level of Continuity
- Cooperation Rules Enable Smaller Countries to Engage Equitably
- Secretariat Provides Means for Staff Support & Management

Challenges:

- Non-Member Major Economies Must Be Engaged in Meaningful Ways
- Key Areas of CC Solutions Require Alliances with Other Parts of OECD
  - » Nuclear Power (NEA, IAES) and Biofuels (OECD)
- CC Technology Charter Must Be Credible and Comprehensive
  - » Non-CO2 Gases (CH4, N2O, SF6, HFCs), Forestry, Agriculture, Land Use
- Need for Strong Central Management to Ensure Progress & Productivity

IEA Technology Organization



Source: ***IEA Activities for Energy Technologies 2002 – 2004***

Summary of Challenges

Need for a Common, Visionary, Long-Term Approach, to UNFCCC Goal

Need to Accelerate Progress Toward Low-Emissions Future

One Mode is to Improve Performance, Reduce Costs of Low GHG Techs via:

- More Country RD&D ?
- More International Collaborative RD&D ?
- More Private Sector RD&D ?
- More Technology Push and Technology Pull ?
- New Models for Funding and Incentivizing RD&D ?

Expand Opportunities for S&T Cooperation Among:

- Business, Industry, Nation States, and Others
- Research Institutions and Academia
- Cooperative Frameworks with S&T Actions Abroad

Form Multi-Lateral R&D Collaborations via:

- Goal Sharing, Road Mapping, Division of Labor, Multi-Lateral Invest.

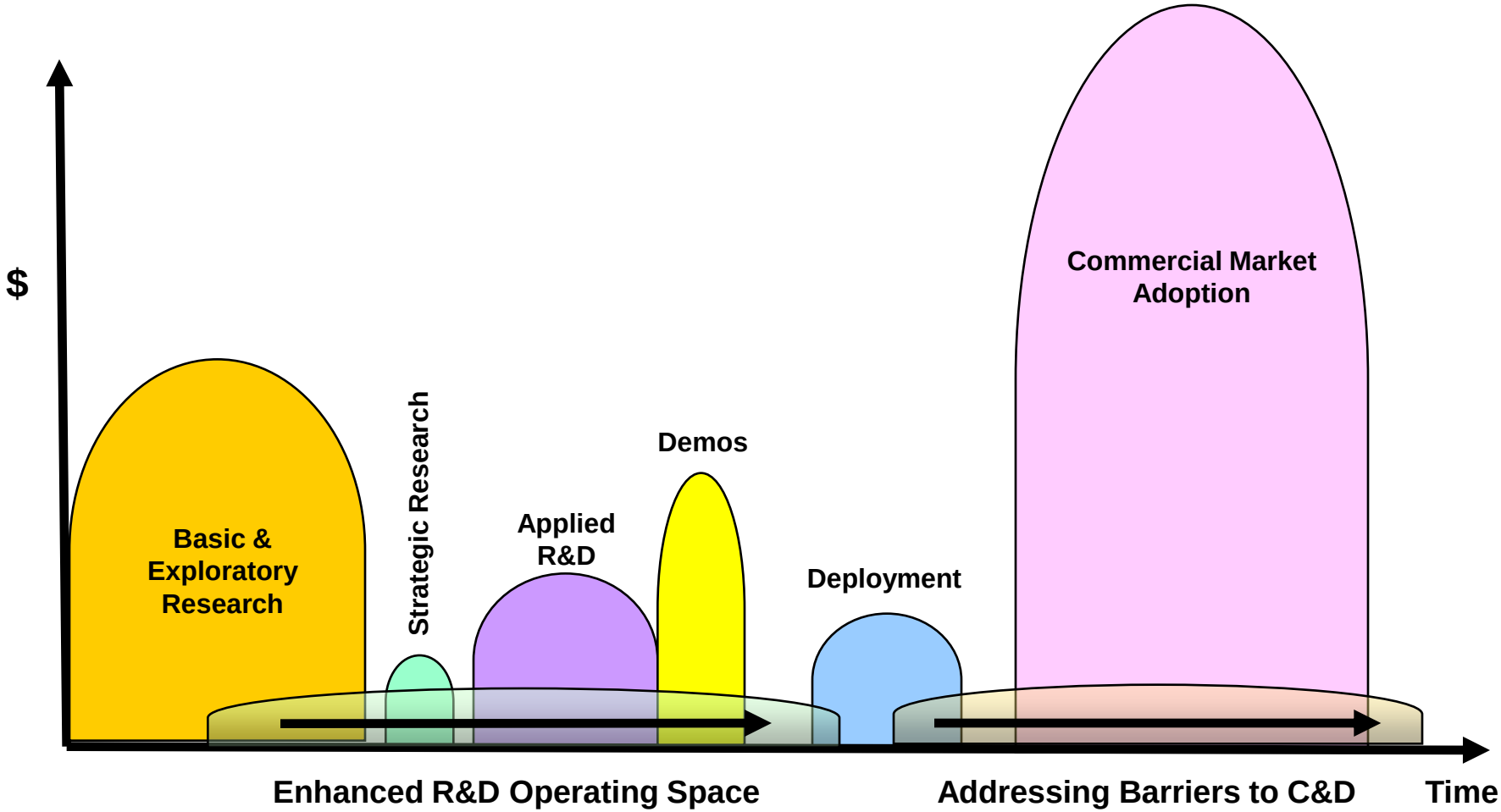
Support Deployment via Finance & Trade on Clean Energy

Build a Bridge to Low-Emissions Future with Broadened Public Support

Back-Up Slides

Do We Need New R&D Management Constructs?

Are Existing R&D Management Structures Sufficient to Speed Progress and Address Key Barriers?



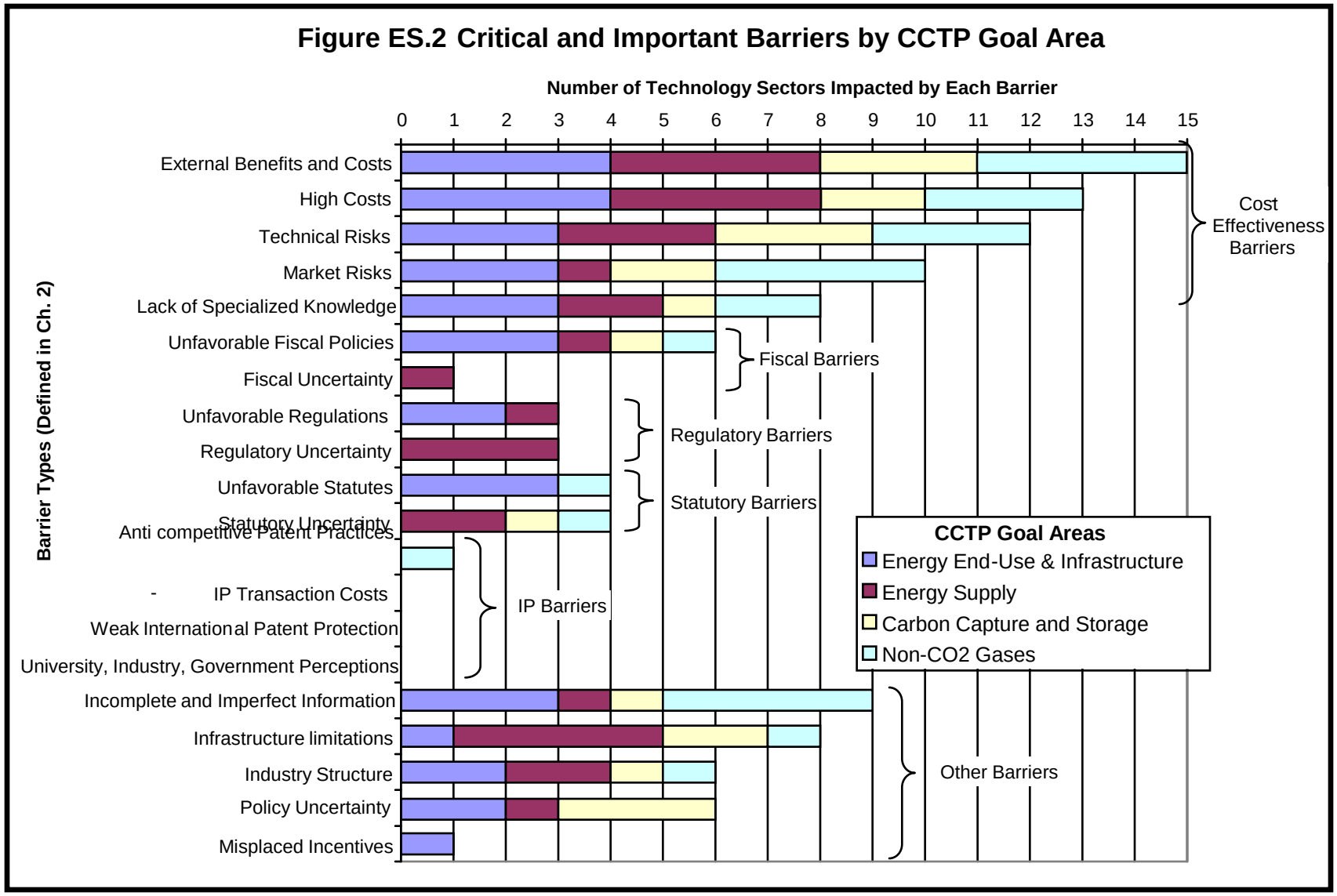
Barriers Typology

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

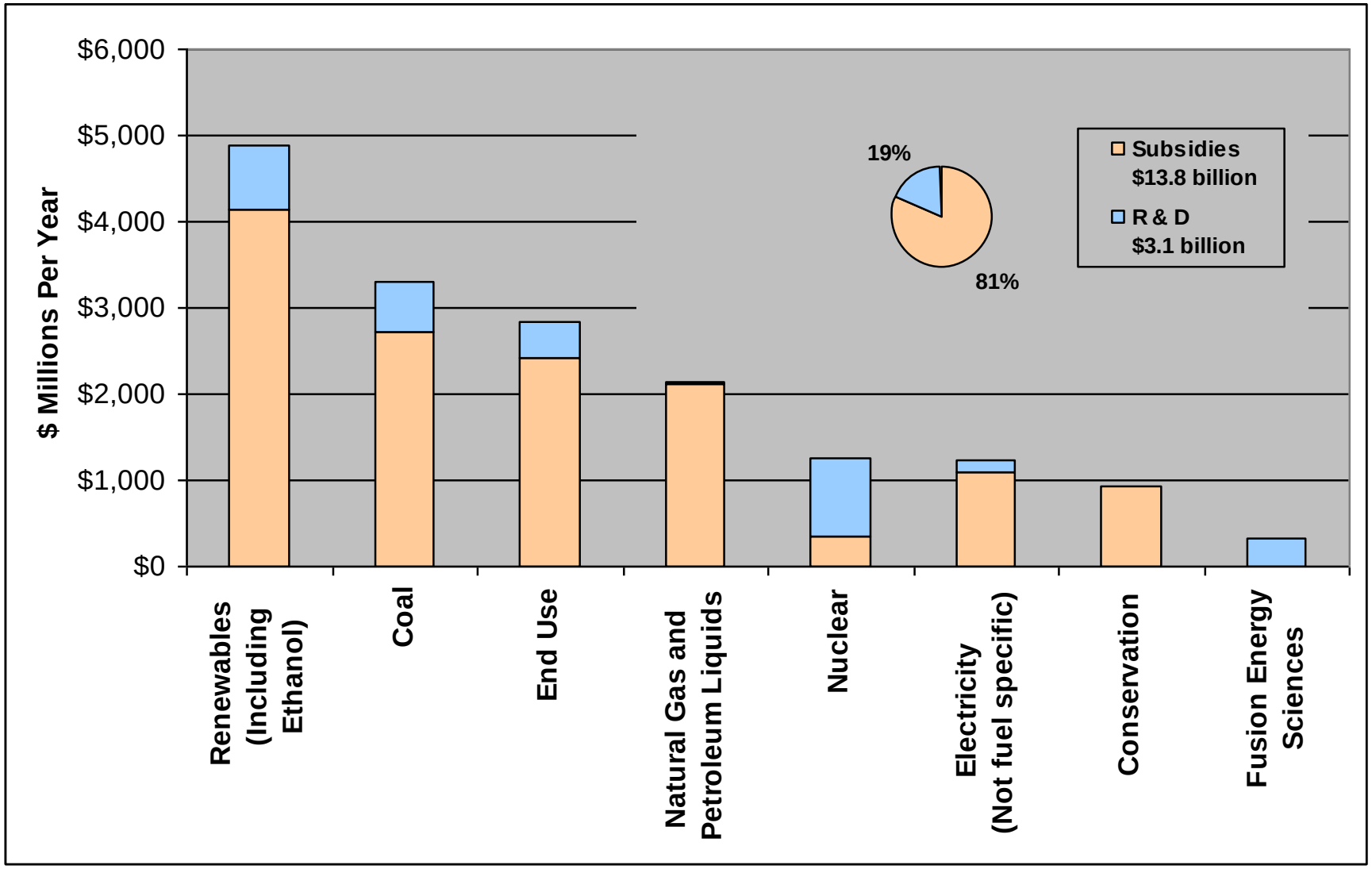
6 Barrier Categories
21 Barriers
~50 Detailed Barriers

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

Barriers – Summary of Findings



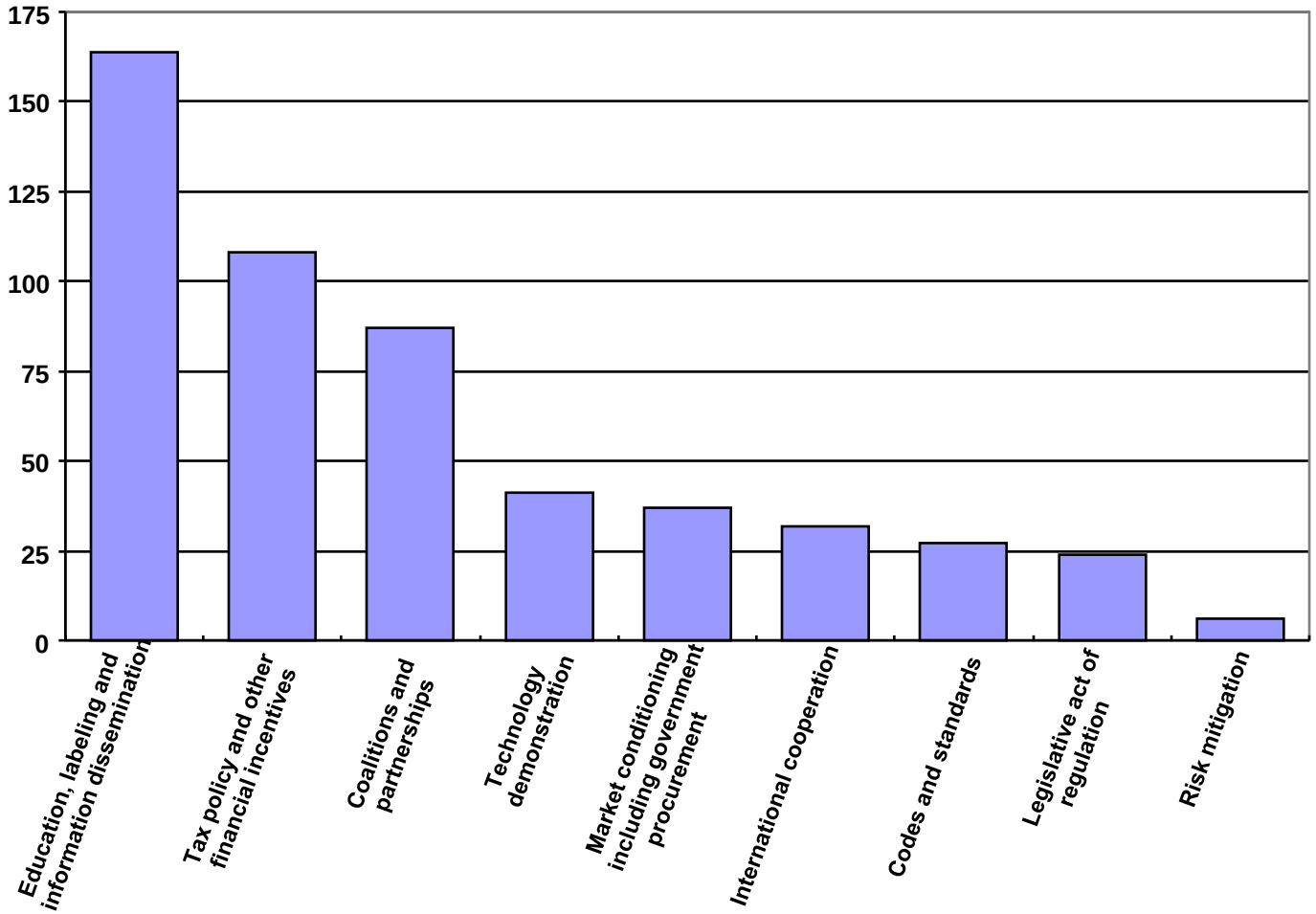
Federal Financial Interventions and Subsidies in Energy Markets FY 2007



Source: Energy Information Administration "Federal Financial Interventions and Subsidies in Energy Markets 2007, SR/CNEAF/2008-01, April 2008"

Commercialization & Deployment Activities, by Category or Genre

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



Policy Process Underway
Some Policy Options, by Technology Area

Technology Areas	Tax Policy and Financial Incentives	Legislative Acts and/or Regulation
Coal w/CCS	Loan Guarantees; Tax Incentives; Cost-Shared Partnerships	CO_2 Storage – Siting & Permitting; Monitoring and Verification; Liability Indemnification; New Source Review Revisions; Access to Public Lands; Property Rights for Subsurface Areas
Nuclear Fission	Loan Guarantees; Production Tax Credit; Standby Support for Certain Delays	Liability Indemnification; Standard Design Certifications; Early Site Permits; Combined Construction & Operating License; Waste and Fuel Management and Storage
Electric Grid and Infrastructure	Loan Guarantee Program, Waste Energy Recovery Incentive Grants*; SmartGrid Investments Matching Grants*; Additional Incentives for Investments (including Cost Recovery Mechanisms)	Public Utilities Regulatory Policies; Renewable and Distributed Generation Code and Standards; Transmission Pricing (Rate Structures); National Transmission Corridors; SmartGrid Code and Standards*; Utility Energy Efficiency Programs*; Standard Net Metering and Interconnection Policies; Siting Access Rights; Access to Meter and Other Data;
Transportation	Tax Credit; Manufacturing Credit; Consumer Incentives, Manufacturing Incentives*	National Regulatory Policies; Urban and Land Use Planning; CAFÉ*; Federal Fleet*
Hydrogen	Loan Guarantees; Alternative Motor Vehicle and Alternative Fuel Infrastructure Tax Credits; Investor Incentives; Insurance	Safety, Codes & Standards; Stationary Fuel Cell Permitting
Bio-Based Fuels	Credit for installing alternative fuel refueling; Loan Guarantees; Production Tax Credit; Development Grants*	Stable Financial Incentives; National Regulatory Policies; Biofuels Tariff; Federal Fleet*, Standard specifications for fuels*
Wind Power	Loan Guarantees; Production Tax Credit; Clean Renewable Energy Bonds; Development Grants*;	Manufacturing Partnerships*; Stable Financial Incentives; Mandated Federal Procurement of Wind Power;
Industry	Loan Guarantees; Efficiency Tax Credits; Sector Specific Tax Credits	Equipment Standards; Emissions Regulations; Informational Partnerships (e.g.; Manufacturing Extension Partnership), Energy-intensive industries program*
Buildings	Manufacturer and Consumer Efficiency Tax Credits, Tax Deductions for Commercial Buildings; Accelerated Depreciation	Federal appliance and equipment standards; Building Codes*; Government Procurement, Federal Buildings Standards*
Solar Power	Loan Guarantees; Business Energy Tax Credit; Residential & Business Solar Investment Tax Credit; Clean Renewable Energy Bonds; Development Grants*; Production Tax Credit	Manufacturing Partnerships*; Stable Financial Incentives; Access to Public Lands (for concentrating solar power installations); Mandated Federal Procurement of Solar Power

Green: Existing Policies
Red: Policy Options