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

Dr. Robert C. Marlay
Deputy Director, U.S. Climate Change Technology Program
Office of Policy and International Affairs
U.S. Department of Energy
robert.marlay@hq.doe.gov

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Part I
U.S. Climate Change Technology Program
“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

Technology Strategy

• 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
    » CO₂ 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

- **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 CO₂; and
  - Reduce emissions from non-CO₂ gases.
- Two cross-cutting, supporting strategic goals:
  - Improve capabilities to measure & monitor GHGs; and
  - Bolster basic science and strategic research.

- **CCTP** authorized in *EPAAct2005*. Led by DOE.
Roadmap for Climate Change Technology Development

<table>
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<tr>
<th>GOAL #1</th>
<th>NEAR-TERM</th>
<th>MID-TERM</th>
<th>LONG-TERM</th>
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</table>
| 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 H₂ 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  | IGCC Commercialization  
• Stationary H₂ Fuel Cells  
• Cost-Competitive Solar PV  
• Demonstrations of Cellulosic Ethanol  
• Distributed Electric Generation  
• Advanced Fission Reactor and Fuel Cycle Technology | FutureGen Scale-Up  
• H₂ Co-Production from Coal/Biomass  
• Low Wind Speed Turbines  
• Advanced Bioraffineries  
• Community-Scale Solar  
• Gen IV Nuclear Plants  
• Fusion Pilot Plant Demonstration | Zero-Emission Fossil Energy  
• H₂ & Electric Economy  
• Widespread Renewable Energy  
• Bio-Inspired Energy & Fuels  
• Widespread Nuclear Power  
• Fusion Power Plants |
| GOAL #3  | CSLF & CSRP  
• Post Combustion Capture  
• Oxy-Fuel Combustion  
• Enhanced Hydrocarbon Recovery  
• Geologic Reservoir Characterization  
• Soils Conservation  
• Dilution of Direct Injected CO₂ | Geologic Storage Proven Safe  
• CO₂ Transport Infrastructure  
• Soils Uptake & Land Use  
• Ocean CO₂ Biological Impacts Addressed | Track Record of Successful CO₂ Storage Experience  
• Large-Scale Sequestration  
• Carbon & CO₂ Based Products & Materials  
• Safe Long-Term Ocean Storage |
| GOAL #4  | Methane to Markets  
• Precision Agriculture  
• Advanced Refrigeration Technologies  
• PM Control Technologies for Vehicles | Advanced Landfill Gas Utilization  
• Soil Microbial Processes  
• Substitutes for SF₆  
• Catalysts That Reduce NOₓ 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  | 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

Chevrolet VOLT

Nanotube-Enhanced Ultracapacitor
[MIT, R. Signorelli – March 2005]
“De-Carbonize” the Electric Grid

- Wind, Solar, Biomass, Other
- Nuclear
- Coal IGCC w/ CCS
- Coal w/o CCS
- Gas CC w/CCS
- Gas w/o CCS
- Oil w/CCS
- Oil w/o CCS

Trillion kWh/yr

Years: 2000 to 2100
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\textsubscript{2} GHGs become available;
- Terrestrial carbon sequestration increases;
- The full potential of conventional oil and gas is realized; and
- Hydrogen production technology advances.
Potential Contributions to Emissions Reduction

Costs Must Be Lowered Significantly


* U.S. Climate Change Technology Program Strategic Plan, September 2006, Figure 10-2
### Timing is of the Essence

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<th>CCTP Strategic Goal</th>
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<th>Medium Constraint</th>
<th>Low Constraint</th>
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<td>2030 - 2040</td>
<td>2030 - 2050</td>
<td>2040 - 2060</td>
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<td>2040 or Later</td>
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<td>2050 - 2060</td>
<td>2050 - 2060</td>
<td>2070 - 2080</td>
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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.

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

Emission Trajectories

- 750ppm
- 650ppm
- 550ppm
- 450ppm
- 350ppm

Concentration Trajectories

- 750ppm
- 650ppm
- 550ppm
- 450ppm
- 350ppm

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

# R&D

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<th>CCTP Strategic Plan – Corresponding Technologies in Scenarios Analysis</th>
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<th>Most Challenging Technical Scenario</th>
<th>Units</th>
<th>Scenarios Years &amp; Quantities – U.S. Only</th>
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<td>Buildings</td>
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<td>Renewables and Fuels</td>
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<td>Electricity: Gen III Reactors</td>
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<td>Capturing and Sequestering Carbon Dioxide</td>
<td>Carbon Capture</td>
<td>(Embedded in 2.1)</td>
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<td>Ocean Sequestration</td>
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<td>Reducing Emissions of Non-CO2 Greenhouse Gases</td>
<td>Methane Emissions from Energy and Waste</td>
<td>CH₄ in CO₂-Equivalence</td>
<td>DOE/EPA</td>
<td>CLC 450</td>
<td>GtC-Eq/yr</td>
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<td>Methane and Nitrous Oxide Emissions from Agriculture</td>
<td>TBD – CH₄ (Part)</td>
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<td>Emissions of High Global-Warming Potential Gases</td>
<td>Short-Lived F-Gases in CO₂-Equivalence</td>
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<td>Long-Lived F-Gases in CO₂-Equivalence</td>
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<td>Nitrous Oxide Emissions from Combustion and Industrial Sources</td>
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<td>Emissions of Trophic Heterotrophs Precursors and Black Carbon</td>
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<td>Enhancing Capabilities to Measure and Monitor Greenhouse Gases</td>
<td>MM – Energy Production and Efficiency</td>
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<td>MM – CO₂ Capture and Sequestration</td>
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<td>MM – Other Greenhouse Gases</td>
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<td>MM – Integrated Systems Architecture</td>
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<td>Bolster Basic Science Contributions to Technology Development</td>
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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

Goal 1 End Use
Goal 2 Supply
Goal 3 CCS
Goal 4 Other GHGs
Goal 5 M&M
Goal 6 Science

$4.4 Billion* (Across 10 Agencies)

CCTP Budget History

*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

Quantitative Product

Vision

Strategic Objectives

Identify Barriers

Prioritize Invest’s

Actions & Projects

Qualitative Process

Identify Key Participants

Define Roles and Responsibilities

Build Partnerships

Review & Evaluation

Execute
Carbon Sequestration Technology Roadmap

Ensuring the Future of Fossil Energy Systems through the Successful Deployment of Carbon Capture and Storage Technologies.

CARBON SEQUESTRATION PROGRAM GOAL

- 96% CO₂ Capture
- 99% Storage Permanence
- <10% Increase in Cost of Energy Services

CHALLENGES

- Global climate change
- Cost-effective separation
- Geologic & geographic diversity
- Technology deployment
- Integration
- Permanence
- MM&V
- Permitting
- Public acceptance

RESEARCH PATHWAYS

- Capture
- Storage
- MM&V
- Non-CO₂ GHGs
- Breakthrough Concepts

Advanced fossil fuel conversion systems with near zero impact on the environment
Carbon Sequestration Program Milestones and Goals

1997
- Carbon Sequestration Program initiated.

2001
- First Annual Carbon Sequestration National Conference held.

2003
- Regional Carbon Sequestration Partnerships Program launched.
- Carbon Sequestration Leadership Forum established.

2005
- Began Validation Phase of Regional Carbon Sequestration Partnerships

2006
- Characterization Phase of Regional Carbon Sequestration Partnerships Program completed.

2007
- Identify capture technologies that increase cost of energy services by less than 20% for pre-combustion systems and less than 45% for post-combustion systems and oxy-combustion systems.
- Initiate the Deployment Phase of the Regional Carbon Sequestration Partnerships

2008
- Develop MM&V protocols that enable 95% of stored CO₂ to be credited as net emissions reduction.

2009
- Complete validation phase of Regional Carbon Sequestration Partnerships Program.

2010
- Initiate at least one large-scale demonstration of CO₂ storage (≥1 million tons CO₂/yr) in a geologic formation.

2012
- Develop MM&V protocols that enable 99% of stored CO₂ to be credited as net emissions reduction.
- CARBON SEQUESTRATION PROGRAM GOAL
- Develop fossil fuel conversion systems that offer 95% CO₂ capture with 99% storage permanence at less than 10% increase in the cost of energy services.

2014
- Initiate at least two slipstream tests of novel CO₂ capture technologies that offer significant cost reductions.

2015
- Develop terrestrial sequestration technologies to the point of commercialization at a cost not exceeding $5/metric ton of carbon sequestered.

2016
- Begin at least one demonstration in which CO₂ is sequestered in a saline formation and brine water from the saline formation is recovered for beneficial use.

2020
- Initiate a field demonstration of at least one technology for enhancing the rate of CO₂ mineralization in situ.

2022
- Initiate at least one large-scale demonstration to evaluate the carbon sequestration benefits achieved by integrating biomass gasification and coal gasification.
- Initiate large-scale field testing of promising novel CO₂ capture technologies.
Basic Research Needs Roadmaps


- 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 knowledgebase 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

U.S. DOE Energy RD&D
1978-FY2009 Administration Request

History of Int’l Energy R&D

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
## Potential Areas for Int’l Collaboration

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<td>C&amp;CO₂ Managed Industries</td>
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<td>High-Efficiency, All-Electric Manufacturing</td>
<td>Demonstration of Burning Plasmas</td>
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<td>Energy Storage for Load Leveling</td>
<td>CCS</td>
<td>Fully Operational Sensor and Satellite Networks</td>
</tr>
<tr>
<td>Advanced Controls and Power Electronics</td>
<td>Post Combustion Capture</td>
<td>Low-Cost Sensors and Communications</td>
</tr>
<tr>
<td>Wireless Transmission</td>
<td>Oxygen Separation Technologies</td>
<td>MM Systems Architecture</td>
</tr>
</tbody>
</table>
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

IEA GOVERNING BOARD

CERT – Committee on Energy Research and Technology

IEA Member Countries

IEA Secretariat

Implementing Agreements

Fusion Power Co-ordination Committee
- Implementing Agreements
  - Env. Aspects Fusion
  - Fusion Materials
  - Large Tokamaks
  - Nuclear Tech. Fusion
  - Textor
  - Rev. Field Pinches
  - Stellarator
  - ASDEX Upgrade

Fossil Fuels Working Party
- Implementing Agreements
  - Clean Coal Centre
  - Clean Coal Science
  - Enhanced Oil Recovery
  - Fluidised Bed Conv.
  - Greenhouse Gas R&D
  - Multiphase Flow Science

Renewable Working Party
- Implementing Agreements
  - Hydrogen
  - Bioenergy
  - Geothermal
  - Hydropower
  - Ocean Energy
  - Photovoltaic Power
  - Solar Heating/Cooling
  - SolarPACES
  - Wind Turbines

End Use Working Party
- Implementing Agreements
  - Adv. Fuel Cells
  - Adv. Materials Trans
  - Adv. Motor Fuels
  - Hybrid-Elec. Vehicles
  - Demand Side Mgmt.
  - Building Conservation
  - District Heating/Cooling
  - Energy Storage
  - Heat Pumps
  - Emissions/Combustion
  - Process Integration
  - Pulp & Paper
  - Superconductivity

Hydrogen Co-ordination Group
- R&D Priority Expert Group
- Basic Science Expert Group

Oil & Gas Expert Group

Intersectors Implementing Agreements
- Climate Technology Initiative (CTI)
- Energy Environmental Technologies Information Centre (EETIC)
- Energy Technology Systems Analysis Programme (ETSAP)
- Energy Technology Data Exchange (ETDE)

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?

![Diagram depicting Enhanced R&D Operating Space and Addressing Barriers to C&D over time.](image-url)
### Barriers Typology

<table>
<thead>
<tr>
<th>Cost Effectiveness</th>
<th>Fiscal Barriers</th>
<th>Regulatory Barriers</th>
<th>Statutory Barriers</th>
<th>Intellectual Property Barriers</th>
<th>Other Barriers</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Costs</td>
<td>Unfavorable Fiscal</td>
<td>Unfavorable Regulations</td>
<td>Unfavorable Statutes</td>
<td>IP Transaction Costs</td>
<td>Incomplete and Imperfect Information</td>
</tr>
<tr>
<td>Market Risks</td>
<td>Unfavorable tariffs</td>
<td></td>
<td></td>
<td>Weak International Patent Protection</td>
<td></td>
</tr>
<tr>
<td>External Benefits and Costs</td>
<td></td>
<td></td>
<td></td>
<td>University, Industry, Government Perceptions</td>
<td></td>
</tr>
<tr>
<td>Lack of Specialized Knowledge</td>
<td></td>
<td></td>
<td></td>
<td>Misplaced Incentives</td>
<td></td>
</tr>
</tbody>
</table>

#### 6 Barrier Categories

- 21 Barriers
- ~50 Detailed Barriers

Barriers are organized into six categories consistent with EPAct 2005 Title XVI.
Barriers – Summary of Findings

Figure ES.2 Critical and Important Barriers by CCTP Goal Area

Barrier Types (Defined in Ch. 2)
- External Benefits and Costs
- High Costs
- Technical Risks
- Market Risks
- Lack of Specialized Knowledge
- Unfavorable Fiscal Policies
- Fiscal Uncertainty
- Unfavorable Regulations
- Regulatory Uncertainty
- Unfavorable Statutes
- Statutory Uncertainty
- Anti-competitive Patent Practices
- IP Transaction Costs
- Weak International Patent Protection
- University, Industry, Government Perceptions
- Incomplete and Imperfect Information
- Infrastructure limitations
- Industry Structure
- Policy Uncertainty
- Misplaced Incentives

CCTP Goal Areas
- Energy End-Use & Infrastructure
- Energy Supply
- Carbon Capture and Storage
- Non-CO2 Gases

Cost Effectiveness Barriers
- Fiscal Barriers
- Regulatory Barriers
- Statutory Barriers
- IP Barriers

Other Barriers

Number of Technology Sectors Impacted by Each Barrier
- 0
- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10
- 11
- 12
- 13
- 14
- 15
Federal Financial Interventions and Subsidies in Energy Markets FY 2007

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

<table>
<thead>
<tr>
<th>Technology Areas</th>
<th>Tax Policy and Financial Incentives</th>
<th>Legislative Acts and/or Regulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal w/CCS</td>
<td>Loan Guarantees; Tax Incentives; Cost-Shared Partnerships</td>
<td>CO₂ Storage – Siting &amp; Permitting; Monitoring and Verification; Liability Indemnification; New Source Review Revisions; Access to Public Lands; Property Rights for Subsurface Areas</td>
</tr>
<tr>
<td>Nuclear Fission</td>
<td>Loan Guarantees; Production Tax Credit; Standby Support for Certain Delays</td>
<td>Liability Indemnification; Standard Design Certifications; Early Site Permits; Combined Construction &amp; Operating License; Waste and Fuel Management and Storage</td>
</tr>
<tr>
<td>Electric Grid and Infrastructure</td>
<td>Loan Guarantee Program, Waste Energy Recovery Incentive Grants*; SmartGrid Investments Matching Grants*; Additional Incentives for Investments (including Cost Recovery Mechanisms)</td>
<td>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;</td>
</tr>
<tr>
<td>Transportation</td>
<td>Tax Credit; Manufacturing Credit; Consumer Incentives, Manufacturing Incentives*</td>
<td>National Regulatory Policies; Urban and Land Use Planning; CAFÉ*; Federal Fleet*</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>Loan Guarantees; Alternative Motor Vehicle and Alternative Fuel Infrastructure Tax Credits; Investor Incentives; Insurance</td>
<td>Safety, Codes &amp; Standards; Stationary Fuel Cell Permitting</td>
</tr>
<tr>
<td>Bio-Based Fuels</td>
<td>Credit for installing alternative fuel refueling; Loan Guarantees; Production Tax Credit; Development Grants*</td>
<td>Stable Financial Incentives; National Regulatory Policies; Biofuels Tariff; Federal Fleet*, Standard specifications for fuels*</td>
</tr>
<tr>
<td>Wind Power</td>
<td>Loan Guarantees; Production Tax Credit; Clean Renewable Energy Bonds; Development Grants*;</td>
<td>Manufacturing Partnerships*; Stable Financial Incentives; Mandated Federal Procurement of Wind Power;</td>
</tr>
<tr>
<td>Industry</td>
<td>Loan Guarantees; Efficiency Tax Credits; Sector Specific Tax Credits</td>
<td>Equipment Standards; Emissions Regulations; Informational Partnerships (e.g.; Manufacturing Extension Partnership), Energy-intensive industries program*</td>
</tr>
<tr>
<td>Buildings</td>
<td>Manufacturer and Consumer Efficiency Tax Credits, Tax Deductions for Commercial Buildings; Accelerated Depreciation</td>
<td>Federal appliance and equipment standards; Building Codes*; Government Procurement, Federal Buildings Standards*</td>
</tr>
<tr>
<td>Solar Power</td>
<td>Loan Guarantees; Business Energy Tax Credit; Residential &amp; Business Solar Investment Tax Credit; Clean Renewable Energy Bonds; Development Grants*; Production Tax Credit</td>
<td>Manufacturing Partnerships*; Stable Financial Incentives; Access to Public Lands (for concentrating solar power installations); Mandated Federal Procurement of Solar Power</td>
</tr>
</tbody>
</table>

**Legend:**
- **Green:** Existing Policies
- **Red:** Policy Options