12th Biennial Asilomar Conference on Transportation Energy and Policy

Can Innovation De-Carbonize Transportation?

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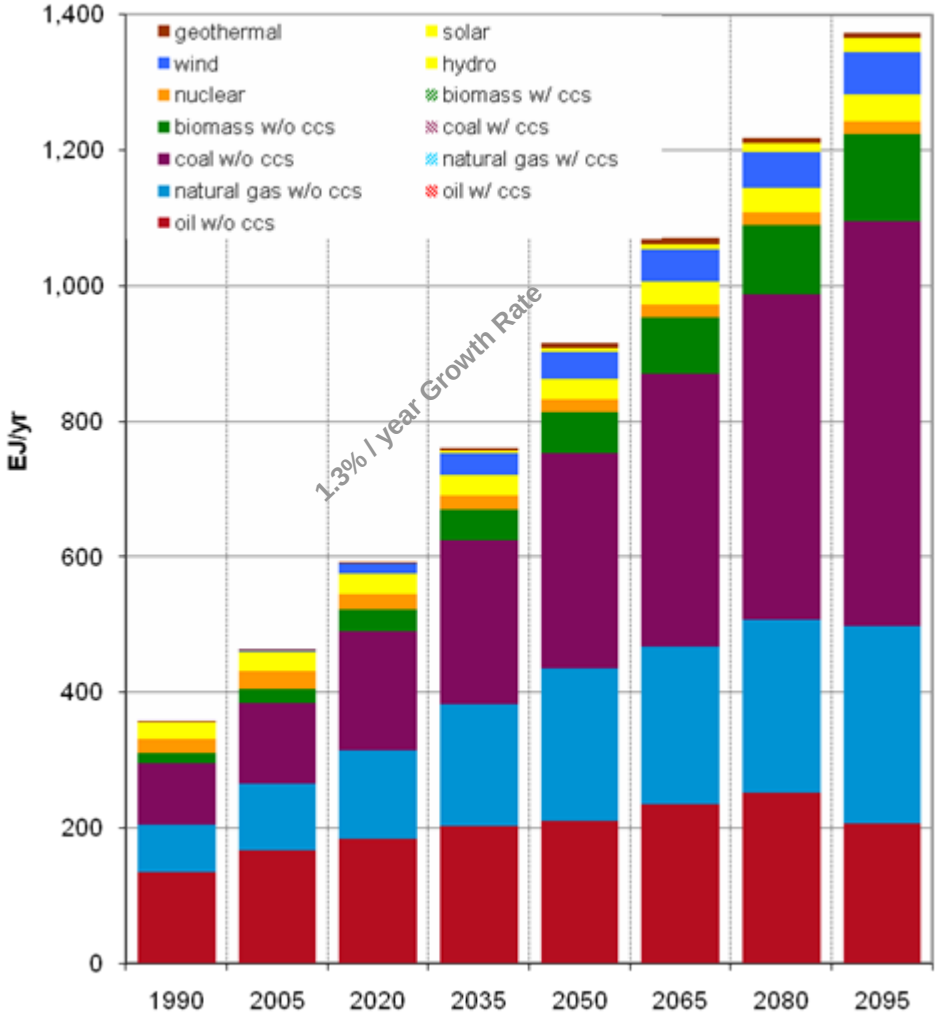
Hosted by the University of California, Davis
Asilomar Conference Center
Pacific Grove, California

*** See: http://www.climatetechnology.gov**

Strategic Context – U.S. and World

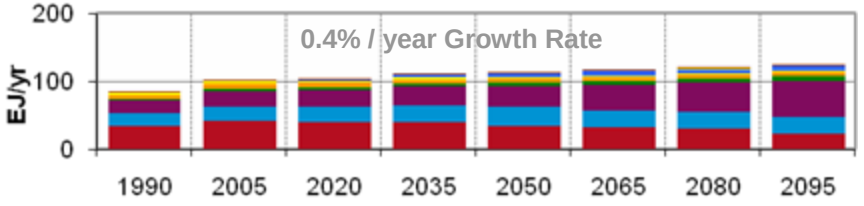
(Reference Case Primary Energy – No GHG Constraints)

World

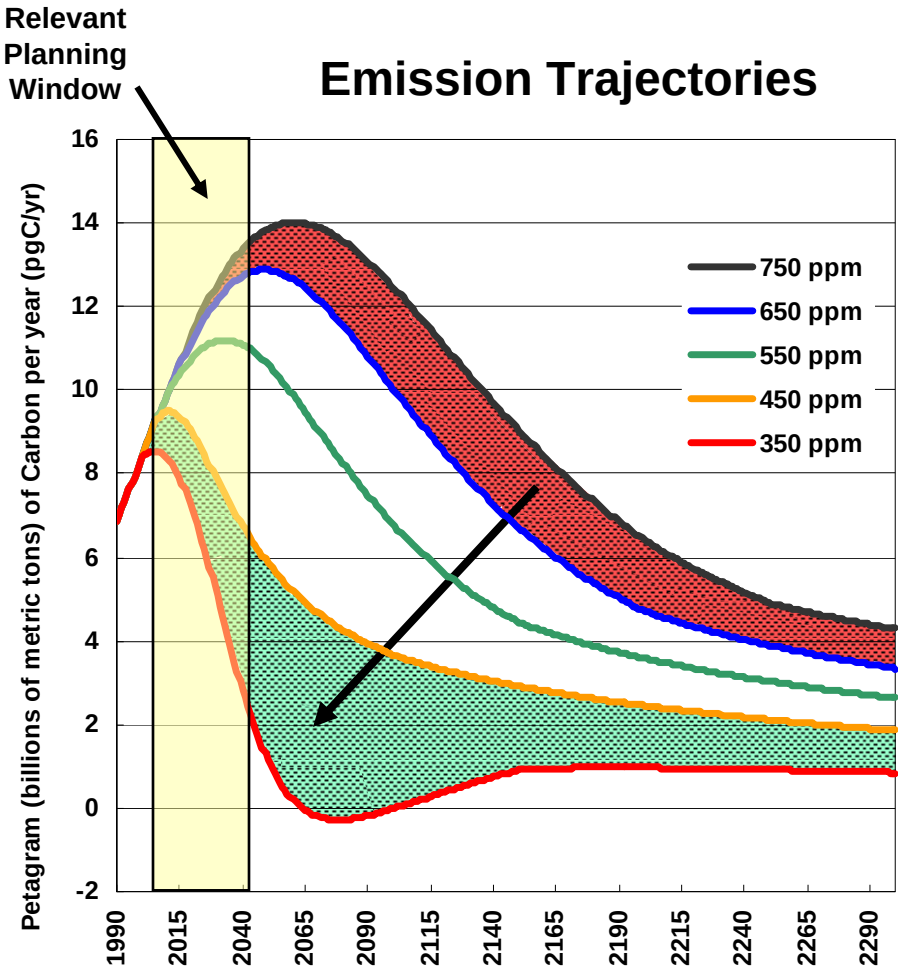


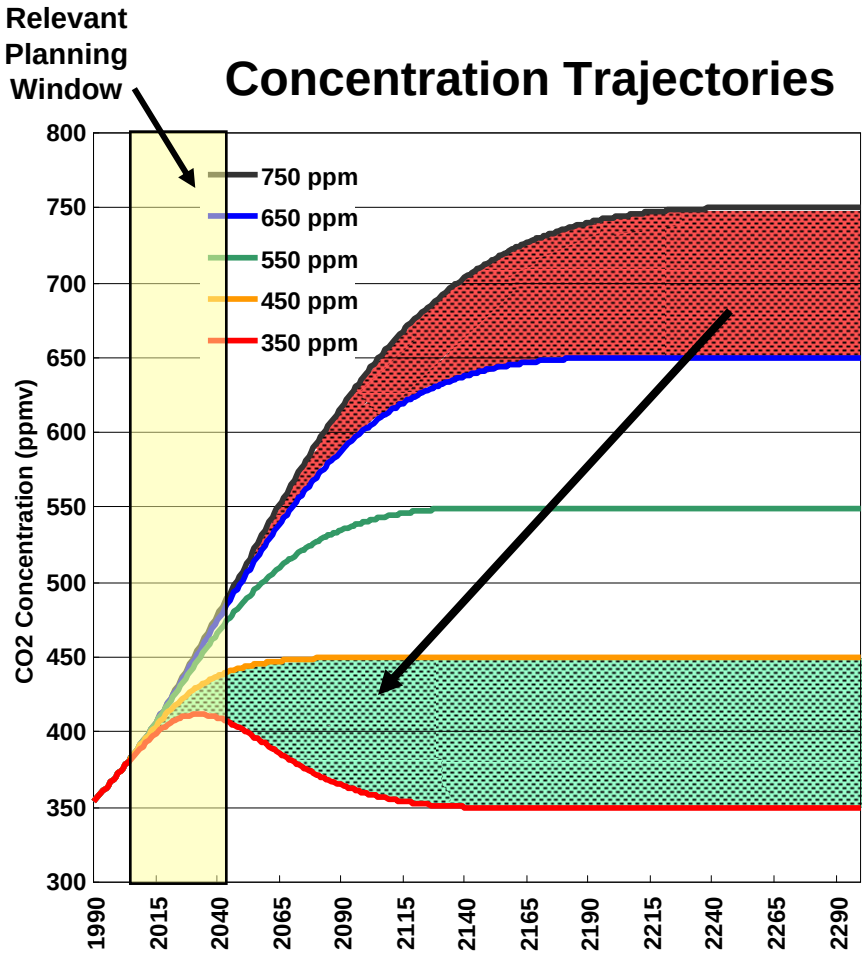
- **World Energy Demand Grows Three-Fold from 2005 to 2100**
- **Reference Case Dominated by Coal, Oil, and Natural Gas (w/out CCS)**
- **U.S. Energy Demand Growth Slows Relative to Rest of World**
- **<u>Key Insight</u>: Strong World Demand Raises Prices; Encourages Efficiency and Use of Energy Alternatives (Bio, Wind, Nuclear, Hydro, and Solar)**

U.S.



Importance of Early Action





Emission and concentration trajectories based on lower level of technology investments/policy actions

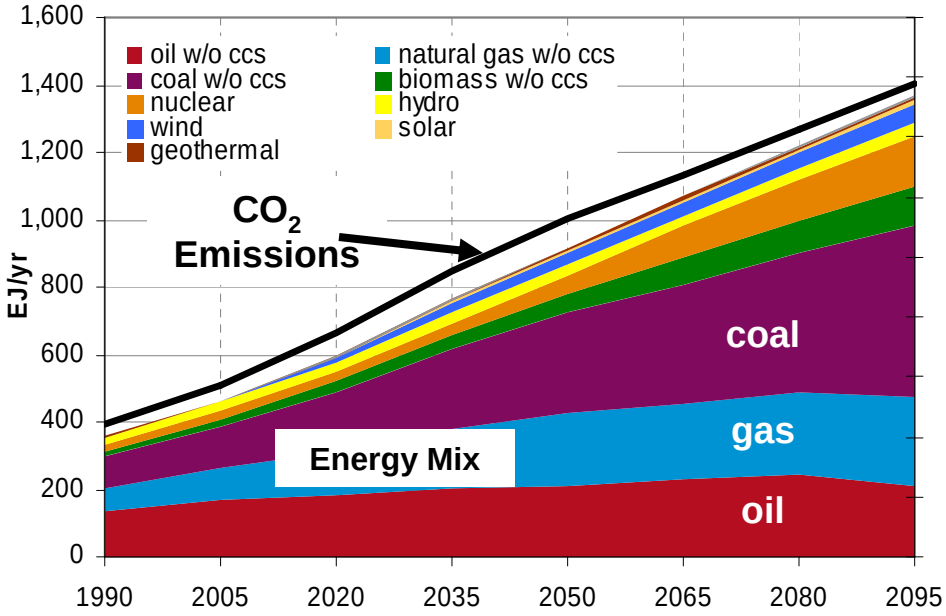
Potential trajectories based on more aggressive technology investments/policy actions

Relevant planning window to influence longer-term outcomes

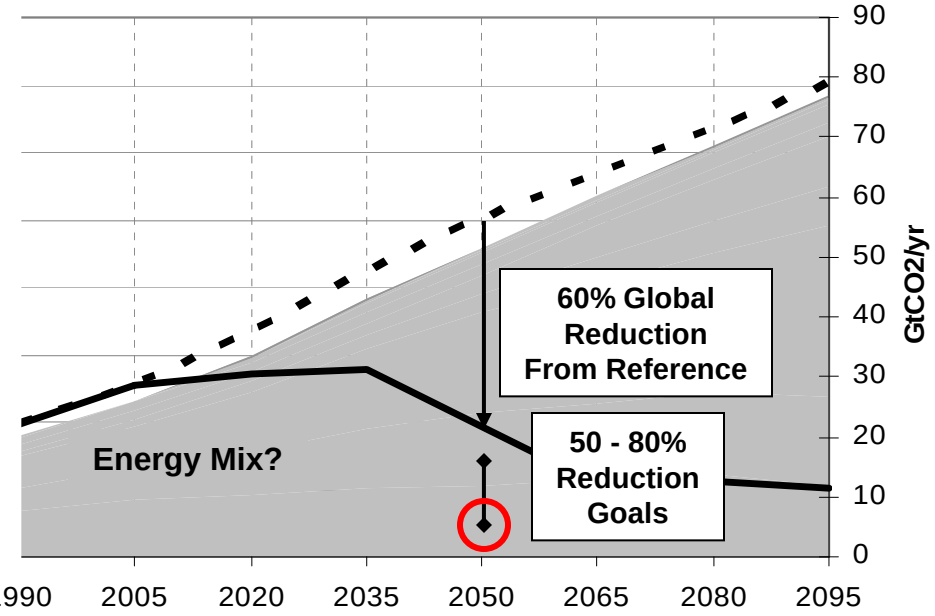
Wigley, Richels, Edmonds, Nature, 1996

Two Global Energy and GHG Emissions Futures

Global Reference Case CO_2 Emissions (No Stabilization)



Constrained Global CO2 Emissions for 450 ppm CO_2 Stabilization



Reference Case

- No Reduction in Carbon Intensity of Energy, so Emissions Grow at Same Rate
- Energy System Dominated by Coal, Oil, and Natural Gas

Stabilization Case

- Graph shows reductions consistent with 450 ppm CO2 concentration (~550 ppm CO2-eq.)
- Requires global reductions of 60% below projected emissions in 2050 (25% below 2005 levels)
- Achieving a 50 – 80% reduction consistent with 450 ppm CO2-eq. is more aggressive

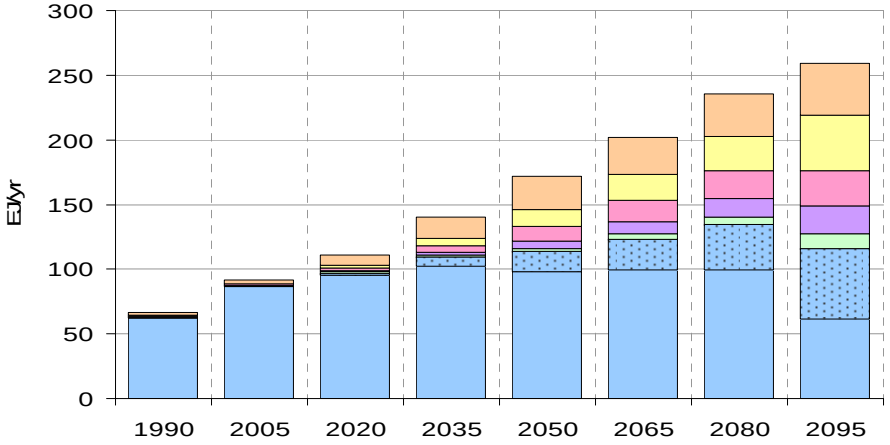
Transformational Transportation Strategies

	Strategy	Elements
A.	Vehicle Energy Efficiency	Highway Vehicle Technology, Anti-Idling, CAFÉ, Fee-bates, Inspection & Maintenance, Rail, Marine, and Aviation
B.	Alternative Fuel Solutions	Ethanol (Cellulosic, Corn, etc), Biodiesel, CNG, LNG, H2/Fuel Cells, Alternative Jet Fuels, Electricity, Hydrogenated Fuels, Di-Methyl Ethylene
C.	Transportation System Efficiency	Operations: Anti-Idling, LCVs, Weight Limits, Aviation (NEXTGEN), Information & Information Technology, Bottleneck Relief, Infrastructure, Construction & Maintenance Market, Regulatory & Education: Congestion Pricing, Cordon Pricing, PI & Driver Education, Reduced Speed Limits Interactions with VMT Strategies
D.	Transportation Demand Management	VMT/ Travel Behavior: Intercity Tolls, VMY Fees, PAYD Insurance, Demand Management, PI – Cost of Driving/Flying, Tele-work, Compressed Work Week, Flexible Work Schedules, Freight (Urban Consolidation Centers), Market, Regulatory, and Education Mode Choice: Demand Management, Transit Expansion, Promotion, Service, Ride-Matching, Carpool, Vanpool, Non-Motorized Transport, Freight (Modal Diversion), Intercity Passenger Rebound Effects: Land Use: Scenario Planning, Infrastructure Development and Technical Assistance
E.	Economy-Wide Market Incentives	Cap & Trade, Carbon Taxes, Motor Fuel Taxes
F.	Infrastructure Planning & Investment	Changes to State & Metropolitan Planning, Emission Budget Mechanisms for Areas or Economic Sectors, Structure of Government Spending on Transportation

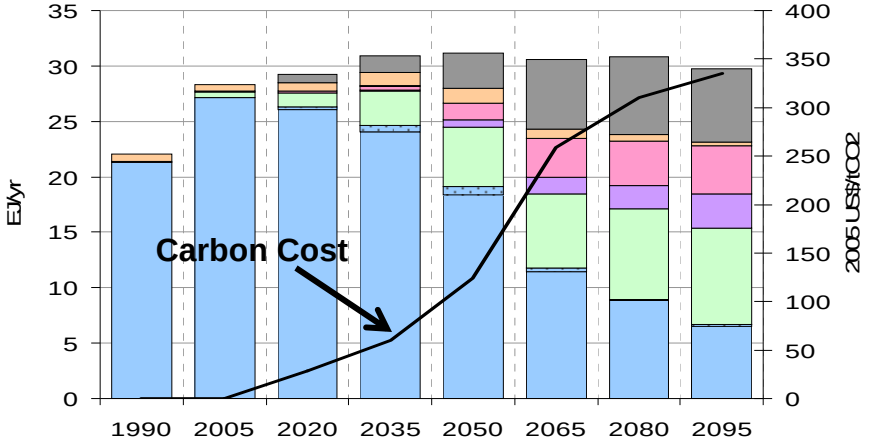
***Report to Congress on Transportation's Impact on Climate Change and Solutions*, as mandated by EISA 2007; Cambridge Systematics, ERG Inc., Energy and Environmental Research Associates, and Parsons Brinkerhoff, under auspices of DOT's Ctr for Climate Policy. Draft Jul 2009.**

Advanced Transportation Technologies Make Progress toward Goal Attainment More Affordable

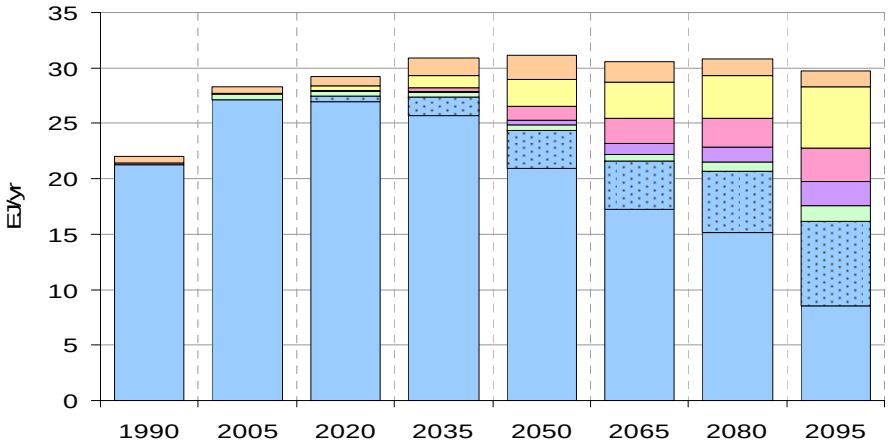
Transportation Fuels Production by Fuel Global Reference Case



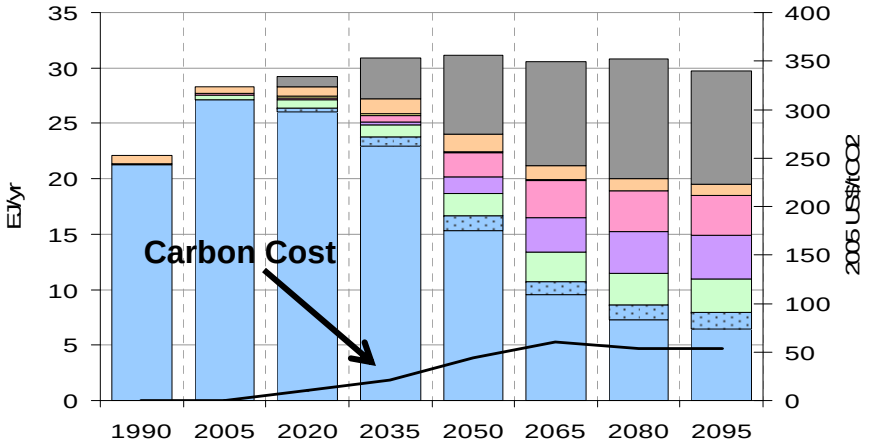
U.S. Transportation Fuel Mix and Carbon Cost for 450 ppm CO2 Constraint (Ref. Technology Case)

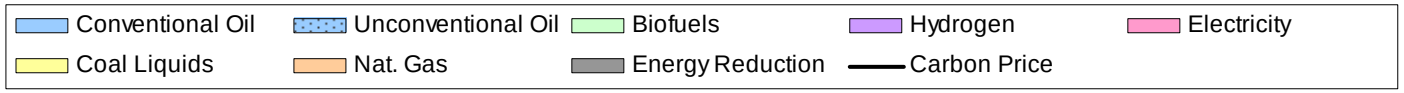


Transportation Fuels Production by Fuel U.S. Reference Case

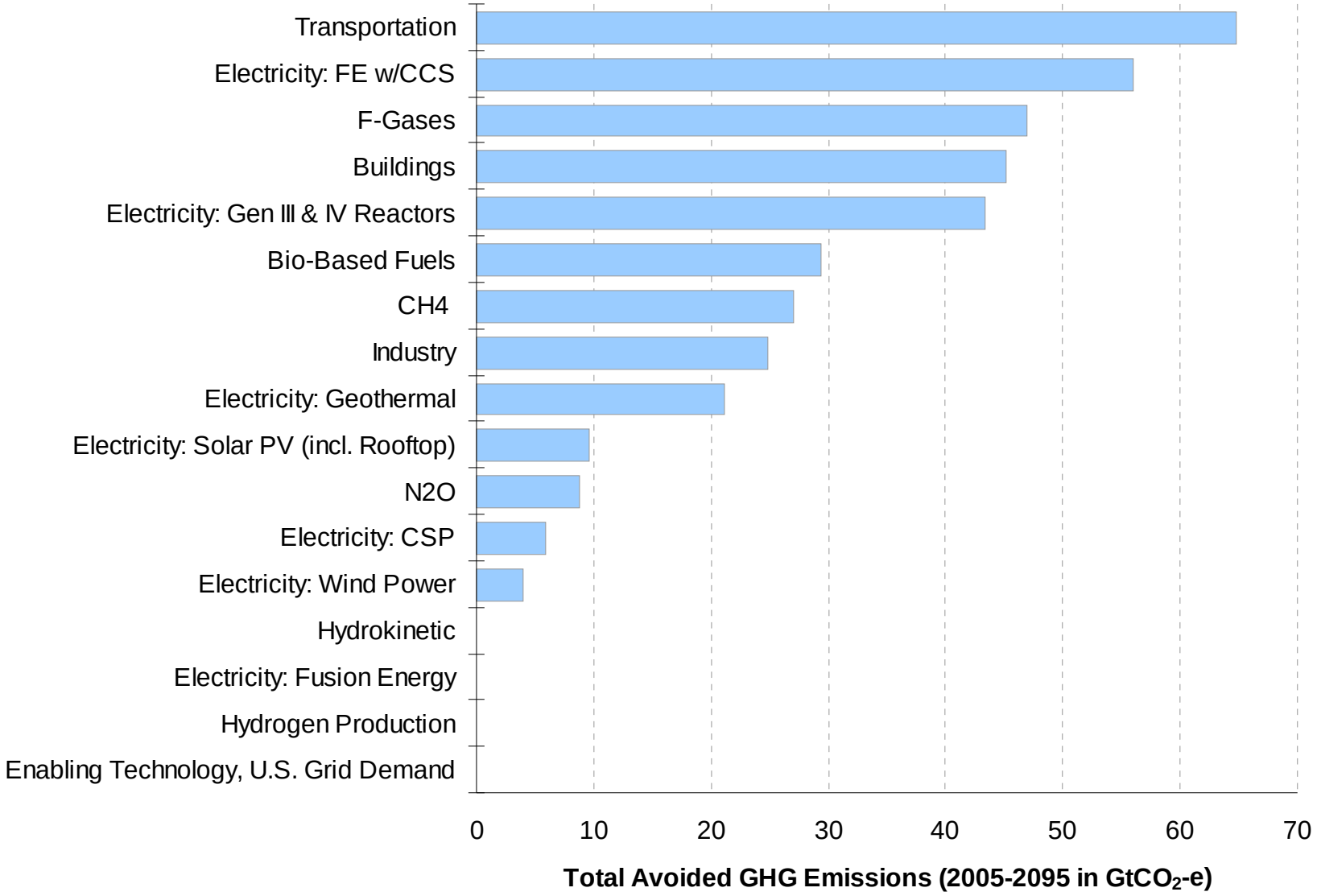


U.S. Transportation Fuel Mix and Carbon Cost for 450 ppm CO2 Constraint ("All-In" Adv. Tech. Case)





Cumulative U.S. GHG Reductions 2005-2095, With Advanced Technologies



If Advanced Technology Is Important, and the Pace Is Too Slow, What Spurs Innovation?

- Market-Based Pricing of Externalities, Where Prices May Be Too Low
  - Environment, Safety and Health
  - Energy and National Security
  - Economic Growth
  - Climate Change
- Traditional Approaches, Where More Can Be Done
  - Federal R&D
  - Financial Incentives
  - Policies to Address Non-Price, Non-Technical Barriers
- Additional and Experimental Options
  - Innovation Experiments, ARPA-E and Others
  - House Legislation
  - Senate Legislation
  - G8/MEF Initiatives on International R&D Cooperation and Collaboration

Federal R&D -- Advanced Technologies for High Efficiency Clean Vehicles

Hybrid Electric Systems

- Advanced Batteries
- Power Electronics/ Inverters/Controllers & Motors
- Systems Analysis and Testing
- Aerodynamics, Rolling Resistance & Accessory Loads
- Super-Ultra Capacitors

Tech Introduction

- EPAct/EISA
- Rulemaking
- Deployment
- Validation
- Student Competitions
- Graduate Automotive Technology Education

Advanced Combustion Engine R&D

- Low Temp. Combustion R&D
- Emission Controls
- Light- & Heavy-Duty Engines
- Waste Heat Recovery
- Health Impacts

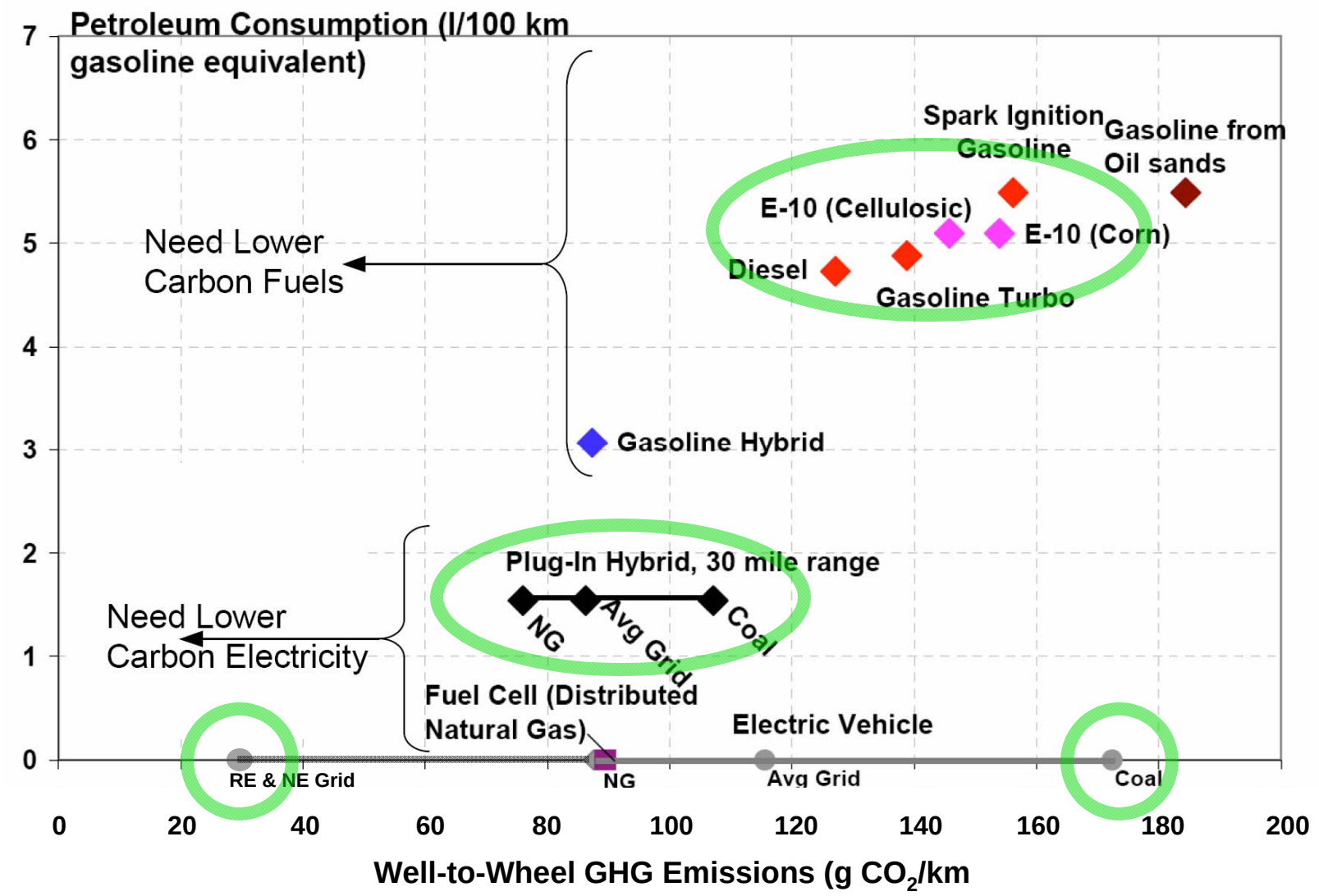
Fuels Technology

- Bio-Based Fuels
- Clean/Efficient Combustion Fuel Characteristics
- Fischer-Tropsch Fuels & Blendstocks
- Advanced Lubricants

Materials Technology

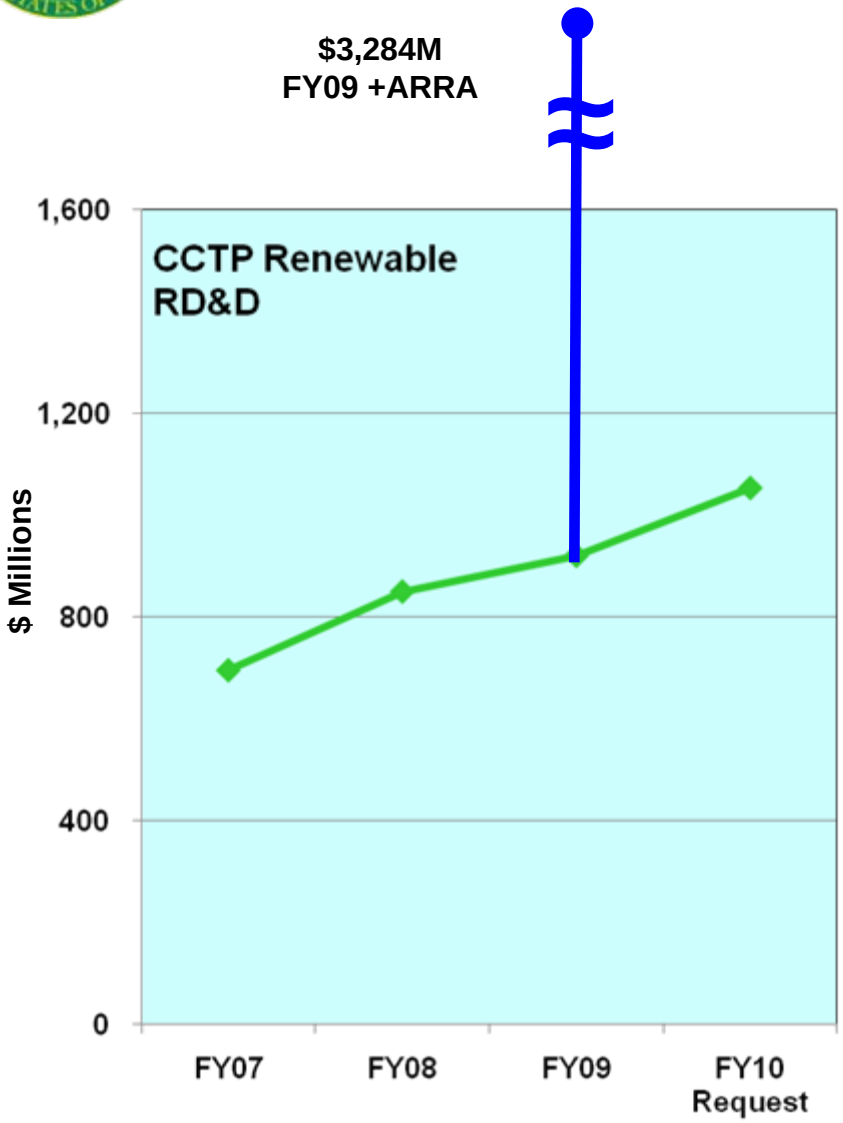
- Lightweight Structures
- Composite Development
- Processing/Recycling/ Manufacturing
- Design Data Test Methods
- High Temperature Materials Laboratory

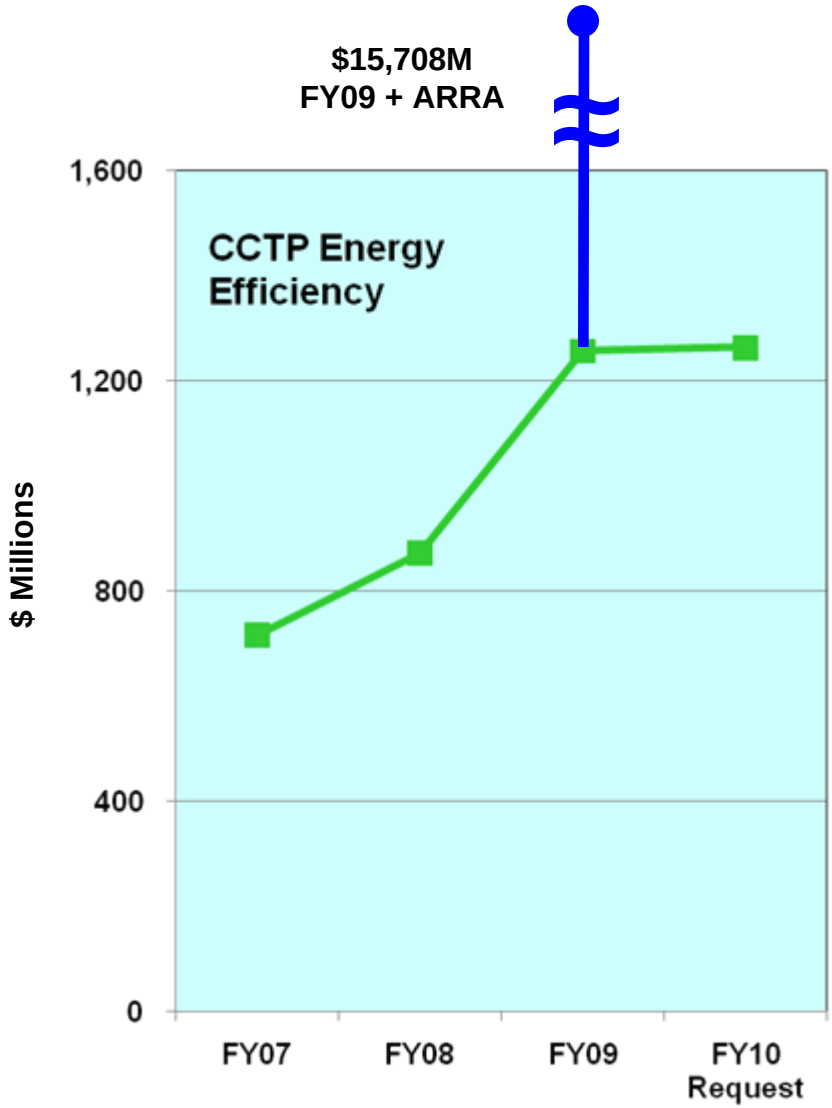
Well-to-Wheels Comparison of Future (2035) Propulsion Systems



International Council on Clean Transportation
MIT Report, "On the Road in 2035"

FY 2007 – FY2010 Renewable Energy and Energy Efficiency





Efficiency and Renewables RD&D + ARRA Funding

Biomass

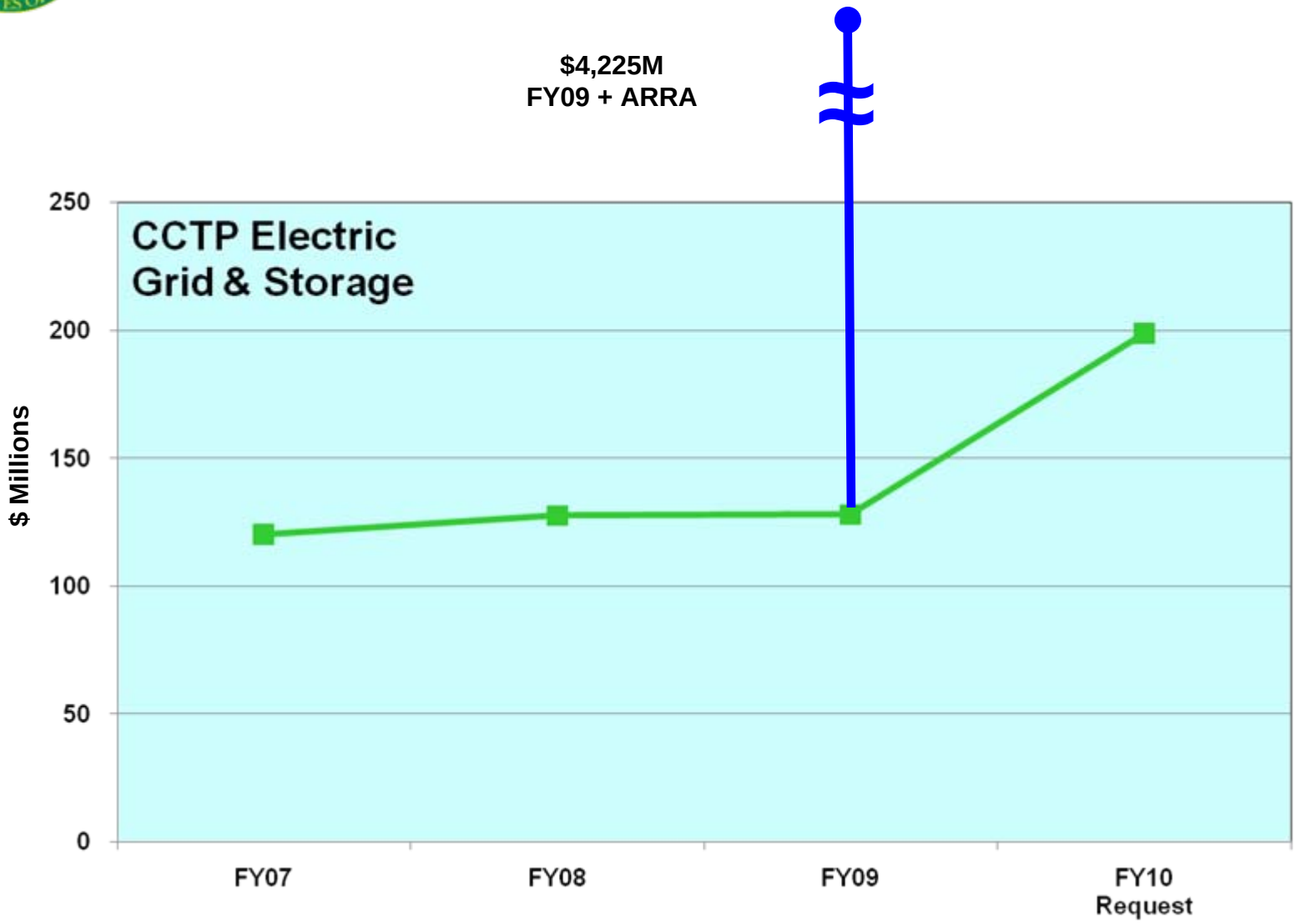
Geothermal

Vehicles-Electric/
Hybrid Electric

- **$19.0B accelerates the transition to a low-carbon economy through increased support of the development and deployment of clean energy technologies, such as solar, biomass, geothermal, wind, and low-carbon emission coal power.**

  - Renewable Energy RDD&D including:
    - » Biomass, Geothermal, Wind, Water, and Solar
    - » Information & Communications Technology
    - » Advanced Battery Manufacturing Grants
    - » Alternative Fueled-Vehicles Pilot Grant Program
  - Energy Efficiency and Conservation
    - » Transportation Electrification
    - » Weatherization Assistance Program
    - » State Energy Program
    - » Energy Efficiency and Conservation Block Grants
    - » Energy Efficient Appliance Rebate Program and ENERGY STAR®

FY 2007 – FY 2010 Electric Grid & Storage



Electricity T&D RD&D + ARRA Funding

- **$4.6B is allotted for investment in a nationwide plan to modernize the electric grid, enhance security of U.S. energy infrastructure and ensure reliable electricity delivery to meet growing demand.**

- **Funds will support:**
  - **Smart Grid technology research, development and demonstration projects;**
  - **Workforce Training;**
  - **Resource assessment and analysis of future demand and transmission requirements;**
  - **Development of interoperability standards for smart grid devices**

Energy Related Priorities for Stimulus
(American Recovery and Reinvestment Act, PL 111-16)

Summary of Energy Investments	Sub-total	Total ($B)
Energy Efficiency & Conservation Block Grants (EECBG)		3.20
State Energy Program		3.10
Weatherization Assistance Program		5.00
Advanced Battery Manufacturing Grants		2.00
Alternative Fueled Vehicles Pilot Grant Program		0.30
Transportation Electrification		0.40
Energy Efficient Appliance Rebate Program – Energy Star		0.30
Energy Efficiency and Renewable Energy Research, Development, Demonstration and Deployment		2.50
Electric Delivery and Energy Reliability Research, Development, Demonstration and Deployment		4.50
Fossil Energy Research and Development		3.40
Science		1.60
Science ARPA-E		0.40
Environmental Cleanup ♣ Non-Defense Environmental Cleanup ♣ Defense Environmental Cleanup ♣ Uranium Enrichment D&D	 0.483 5.127 0.39	6.00
Innovative Technology Loan Guarantee Program ♣ Renewable and Transmission Technologies (EPAct05 temporary program by adding Section 1705)	 6.00	6.00
Inspector General		0.015
DOE Energy Total		38.715
Borrowing Authority Increase for WAPA & BPA		6.5

Financial Incentives

Existing 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

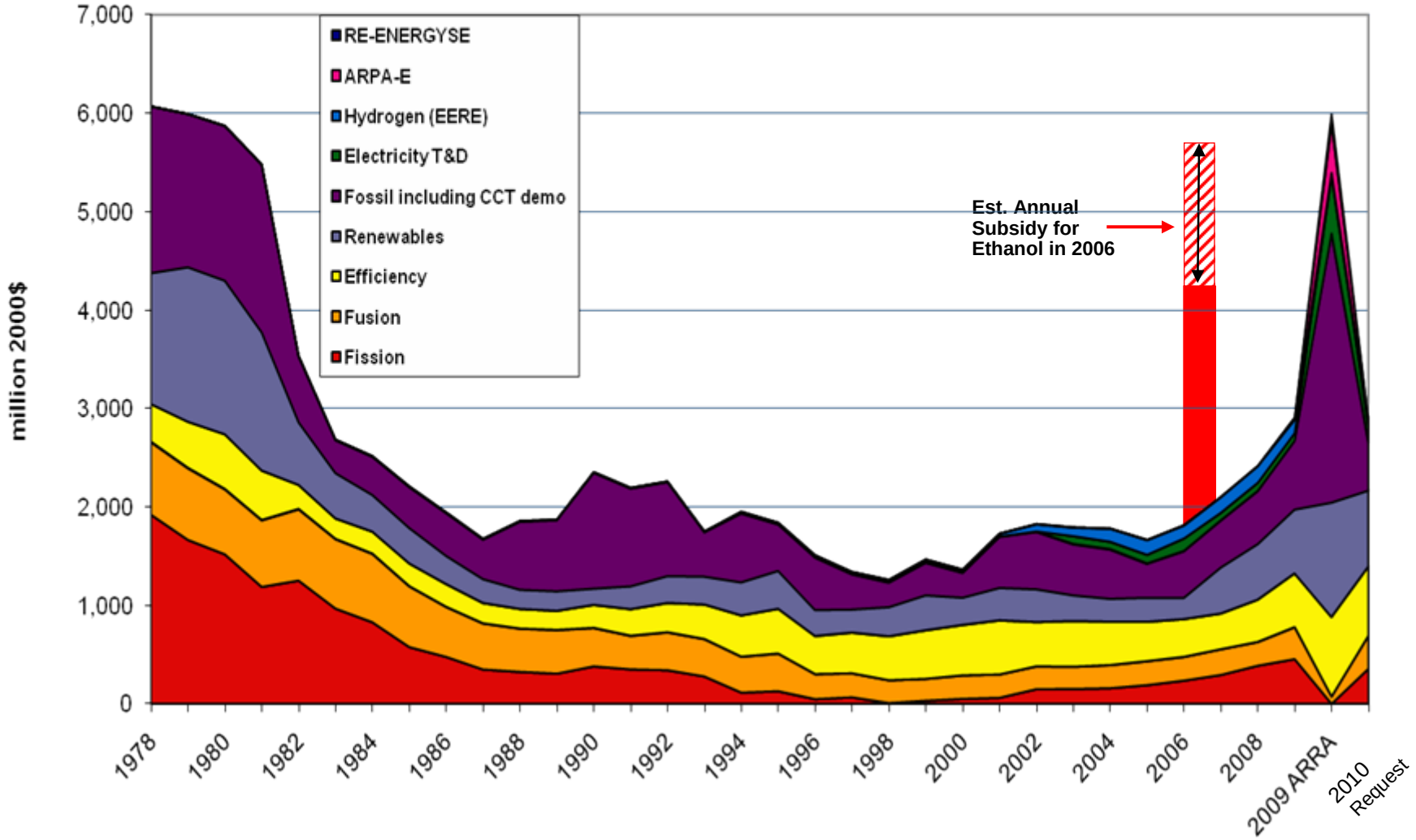
Recent Additions*

- **Efficiency & Transportation**
  - Conservation and Energy Efficiency
  - Tax Credit for Efficient Vehicles
  - Loans for Manufacture of Adv. Technology Vehicles
- **Renewable Energy**
  - Extend Renewable Electricity Production Credit (e.g., Home Solar)
  - Renewable Energy Bonds
  - Ethanol and Biodiesel Tax Credits
- **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, Emergency Economic Stabilization Act of 2008, & FY-2009 CR

U.S. DOE Energy RD&D Budgets

between FY 1978 and the FY 2010 request (including ARRA 2009 funds)



Gallagher, K.S. and L.D. Anadon, "DOE Budget Authority for Energy Research, Development, and Demonstration Database," Energy Technology Innovation Policy, John F. Kennedy School of Government, Harvard University, June 22, 2009. File downloaded at: http://belfercenter.ksg.harvard.edu/publication/19168/doe_fy_2010_budget_request_and_recovery_act_funding_for_energy_research_development_demonstration_and_deployment.html?breadcrumb=%2F

Barriers to Innovative Transformation

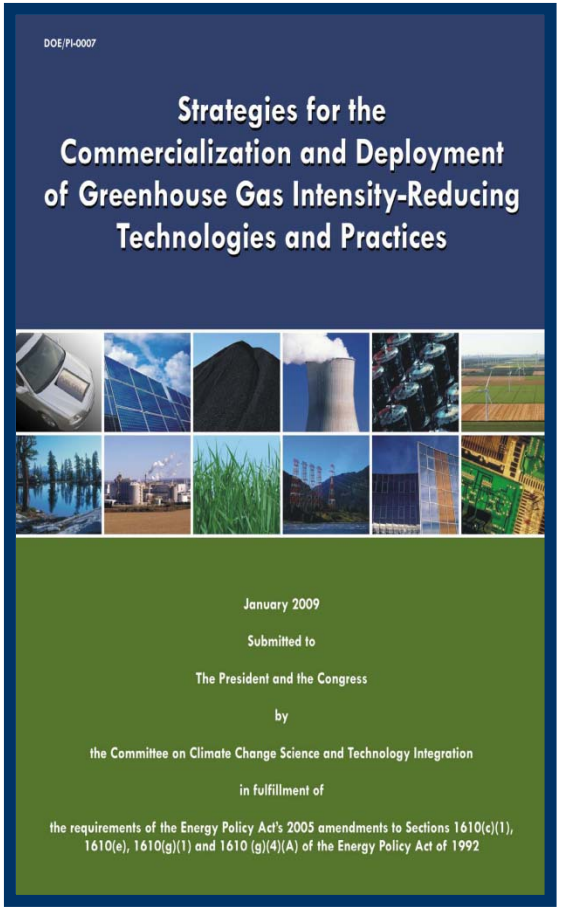
Cost Effectiveness	Fiscal Barriers	Regulatory Barriers	Statutory Barriers	Intellectual Property Barriers	Other Barriers
High Costs	Unfavorable Fiscal	Unfavorable Regulations	Unfavorable Statutes	IP Transaction Costs	Incomplete and Imperfect Information
Technical Risks	Fiscal Uncertainty	Regulatory Uncertainty	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.

Select Federal Activities Addressing Key Technology Deployment Barriers -- Transportation

Key Technology Deployment Barriers	Solutions	
	Major Programs, Policies, or Initiatives*	Illustrative Deployment Activities
Most Critical Barriers:		
Incomplete and Imperfect Information	43	• Clean Cities (DOE) • Green Vehicle Guide (EPA) • Climate Friendly Parks (DOI) • Commuter Choice (DOT, EPA)
High Costs	23	• Alternative Motor Vehicle Credit • Voluntary Airport Low Emission Program (DOT) • Clean Fuels Grant Program (DOE) • Clean School Bus USA (DOE)
Market Risks	17	• Fuel Use Requirement for Federal Vehicles • Hybrid Truck Users Forum (DoD) • SmartWay Transport Partnership (EPA)
Technical Risks	16	• FreedomCAR and Fuel Partnership (DOE) • Advanced Vehicle Testing Activity (DOE) • 21st Century Truck Partnership (DOE)
External Benefits and Costs	15	• Federal Workforce Transportation Benefit • Gas Guzzler Tax
Infrastructure Limitations	13	• Transit Capital Investment Grant Program (DOT) • Alternative Fuel Infrastructure Tax Credit
Competing Regulatory Priorities	7	• Alternative Fuel Infrastructure Tax Credit
Other Important Barriers:		
Lack of Specialized Knowledge	12	• Arterial Management Program (DOT)
Competing Statutory Priorities	1	• Hydrogen Codes & Standards Program (DOE)



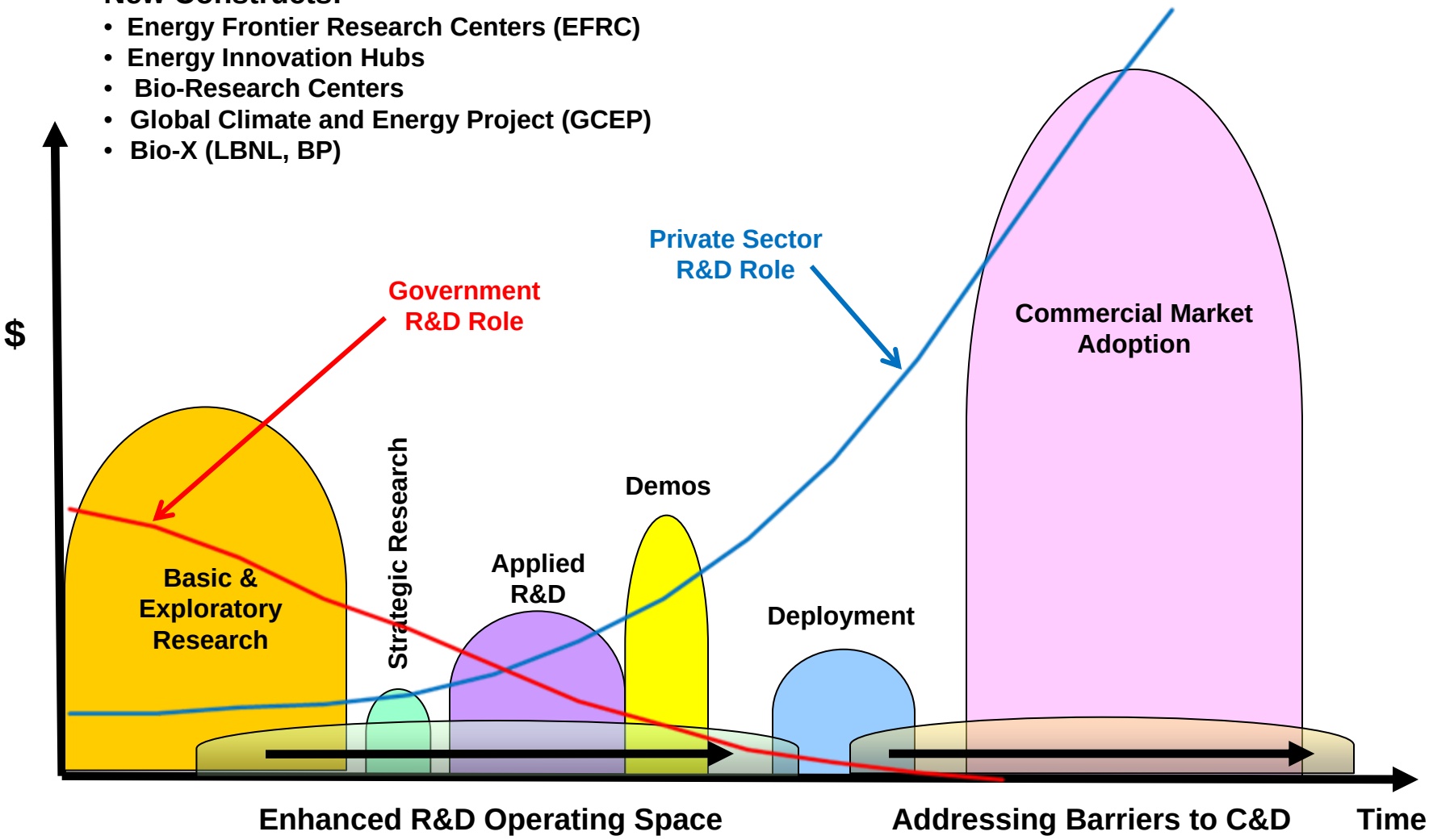
www.climatetechnology.gov

DOE-CCTP, "Strategies to Promote the Commercialization and Deployment of Greenhouse Gas Intensity-Reducing Technologies and Practices," January 2009, DOE/PI-0007

New Technology Innovation Constructs?

New Constructs:

- Energy Frontier Research Centers (EFRC)
- Energy Innovation Hubs
- Bio-Research Centers
- Global Climate and Energy Project (GCEP)
- Bio-X (LBNL, BP)



ARPA-E

- U.S. DOE established the Advanced Research Projects Agency for Energy (ARPA-E)
- Congressed Authorized in 2008. Appropriated $400M in 2009.
- Focus will be on “transformational” and “translational” R&D
- High-risk, high-payoff energy technology R&D to address energy security and climate change
- Follow the model of DARPA and that of AT&T Bell Labs
- Initial Solicitation Closed
- Stats:
  - 3458 Concept Papers Reviewed,
  - 399 Total Reviewers Representing 171 different affiliations

Secretary of Energy

Dr. Steve Chu, with

President Obama

American Clean Energy Leadership Act of 2009

(Senate Committee on Energy & Natural Resources – S. 1462, Bingaman-Murkowski)

Clean Energy Technology Deployment

A. Clean Energy Financing
B. Improved Transmission Siting
C. Federal Renewable Electricity Standard: Ramp to 15% - 2039
D. Energy and Water Integration
E. Vehicle Technology Deployment

Enhanced Energy Efficiency

A. Manufacturing Energy Efficiency.
B. Improved Efficiency in Appliances and Equipment
C. Building Efficiency: Codes, Retrofits
D. Electric Grid

Improved Energy Security

A. Cyber Security of the Electric Transmission Grid
B. Nuclear Energy
C. Improve United States Strategic Reserves
D. Federal Oil and Gas Development
E. Public Land Renewable Energy Deployment
F. Carbon Capture
G. Island Energy: Puerto Rico, Virgin Islands, Guam & American Samoa

Energy Innovation and Workforce Development

A. Funding
B. Grand Energy Challenges Research Initiative
C. Improvements to Existing Energy R&D: $450M Increase in DOE R&D over 5 Years
D. Energy Workforce Development
E. Strengthening Education & Training in Subsurface Geosciences
F. Miscellaneous

Energy Markets

A. Improve Energy Market Information

Policy Studies and Reports

A. Various Resource Assessments
B. Energy Strategy for Tomorrow
C. Climate Change in India & China
D. Renewable Energy Resources
E. Electric Generation Efficiency
F. Emissions of Alternative Transportation Fuels
G. Other Assessments

Other Proposals to Spur Innovation

- **Legislative Proposals:**
  - **Carbon Storage Research Corporation (Boucher)**
  - **Energy Technology Corporation (Deutch, Podesta and Ogden)**
  - **Climate Change Credit Corporation (Lieberman-Warner)**
  - **21st Century Energy Deployment Corporation (Bingaman)**
  - **Clean Energy Investment Bank of the United States (Domenici)**
  - **ARPA-E Enhancements**
  - **Discovery-Innovation Institutes (National Academy of Engineering)**

Lester, R. K., "Reforming the U.S. Energy Innovation System" Industrial Performance Center, MIT, September 2008

DOE-CCTP, "Strategies to Promote the Commercialization and Deployment of Greenhouse Gas Intensity-Reducing Technologies and Practices," January 2009, DOE/PI-0007

Summary

- Ambitious Federal Agenda for Energy, Environment and Climate
- Unprecedented Commitment to Use Any-All Policy Tools in the Kit:
  - Regulation
  - Legislative Mandates
  - Financial Stimulus and Incentives
- Long-Term Integrated Strategies Identify Transportation as a Top-Most Priority, 2nd Only to De-Carbonizing the Electric Grid
- Progress at a Pace Dictated by Science is Uncertain, if Not Unlikely
- An Important "Key" to Progress Remains Technical Innovation
  - Better Remedies at Significantly Lower Costs
  - Breakthroughs in New Areas, at Scale
  - Transformational Concepts that Can Break Deadlocks
- Apart from a High Carbon Price, How to Spur Innovation?
  - Envision the High-Payoff Innovations
  - Take Stock of Existing Policies and Measures
  - Identify Gaps and Formulate Complementary Policy Designs
  - Stimulate the Entire Research Enterprise – Univ., Companies, Labs, Individuals
  - Engage Internationally, Where Possible and Appropriate

Back Up Slides

Am. Clean Energy and Security Act of 2009

(House Energy and Commerce – H.R. 2454, Waxman-Markey)

Title I: Clean Energy

A. Efficiency & Renewable Electricity Standard: 20% by 2020
B. CCS: regulation, deployment, & requirement post-'20
C. Clean Transportation: Electric Vehicles
D. State Energy and Environment Development Funds
E. Smart Grid Advancement
F. Transmission Planning
G. Technical Corrections to Energy Laws: EISA & EPAct05
H. Energy and Efficiency Centers and Research
I. Nuclear & Advanced Technologies: Clean Energy Investment Fund (CEIF), and Clean Energy Deployment Administration (CEDA)
J. Miscellaneous: Hydro, Competition Grants

Title II: Energy Efficiency

A. Building Energy Efficiency : 50% improvement by 2016
B. Lighting and Appliance Energy Efficiency: Best In Class Standards
C. Transportation Efficiency: Heavy & Off-road Vehicles
D. Industrial Energy Efficiency Programs
E. Improvements in Energy Savings Performance Contracting
F. Public Institutions
G. Miscellaneous
H. Energy Efficient Neighborhoods

Title III: Reducing Global Warming Pollution

Amends the Clean Air Act

A. Reducing Global Warming Pollution
- ♣ Target: -17% by 2020, -83% by 2050 below 2005
- ♣ Penalties: double the C-value
- ♣ Price control provision: strategic reserve
- ♣ Offsets: 2 billion tCO2/year allowed
- ♣ Reduced Deforestation

B. Disposition of Allowances
C. Additional GHGs: HFCs & Black Carbon
D. Carbon Market Assurance:
E. Additional Market Assurance: FERC

Title IV: Transitioning to a Clean Energy Economy

A. Real Reductions in Industrial Emissions
B. Green Jobs and Worker Transition
C. Consumer Assistance: low-income energy refunds
D. Exporting Clean Technology
E. Adapting to Climate Change: Climate Services, Public Health, Natural Resource, & International Adaptation

Title V: Agriculture & Forestry Offsets

A. Offset Credit Program
B. USDA GHG Advisory Committee
C. Miscellaneous

Waxman-Markey: ''American Clean Energy and Security Act of 2009'', as submitted to the Senate

Transportation Policies and Measures