U.S. Approach to Climate Change

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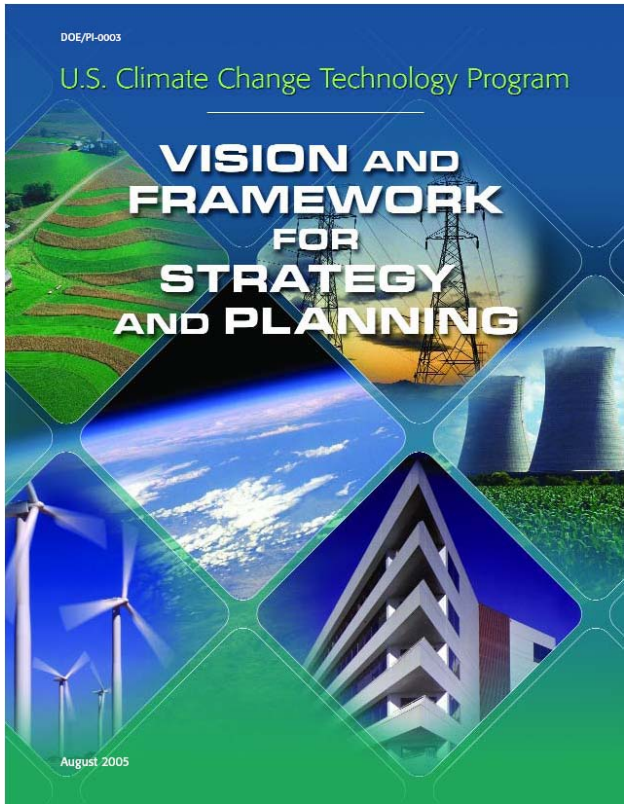
U.S. Department of Energy

Addressing Climate Change --
A German-American Dialogue

The Climate Institute, Washington, DC
26 October 2006

The U.S. Approach to Climate Change

- Presidential Leadership
- Cabinet-Level Engagement
- Near-Term Actions
- Financial Incentives for Investment
- $5 Billion / Year In Federal S&T
  - Science to Inform Policy
  - Advanced Technology to Facilitate Action
- International Initiatives
- Deliberate Approach to Long-Term Goal, Consistent with UNFCCC and International Development Goals
- A Path Forward



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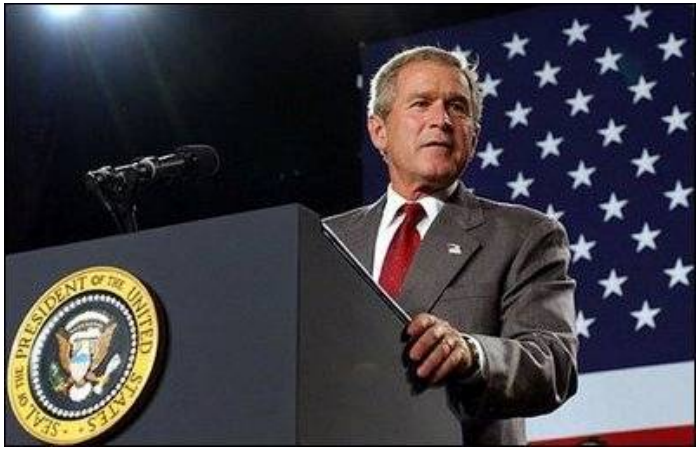
Presidential Leadership . . .



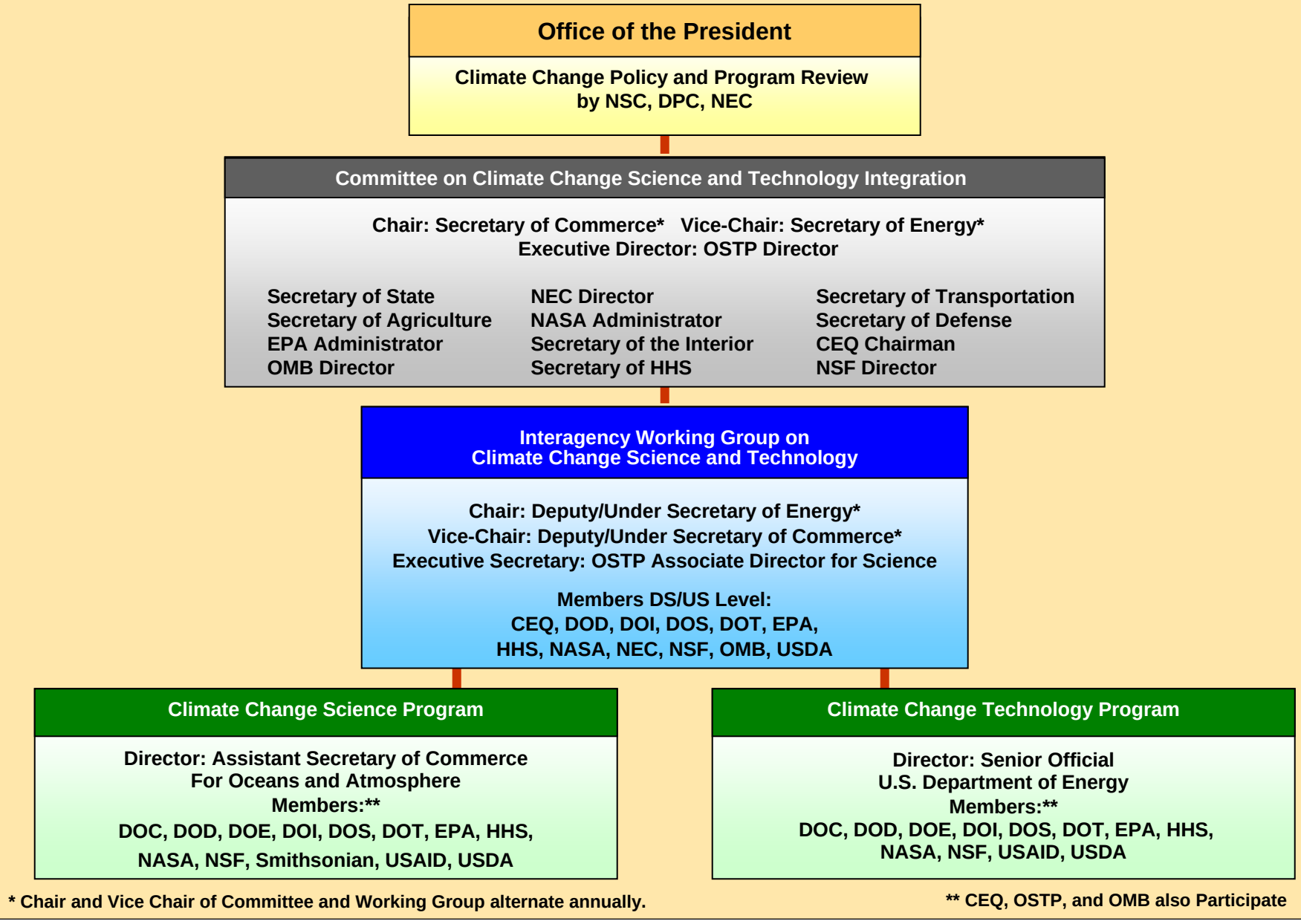
"I reaffirm America's commitment to the United Nations Framework Convention and its central goal, to stabilize atmospheric greenhouse gas concentrations at a level that will prevent dangerous human interference with the climate."

"(We will) set America on a path to slow the growth of our greenhouse gas emissions and, as science justifies, to stop and then reverse the growth of emissions."

- President George W. Bush
February 14, 2002

25 October 2006

Cabinet-Level Engagement



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

** CEQ, OSTP, and OMB also Participate

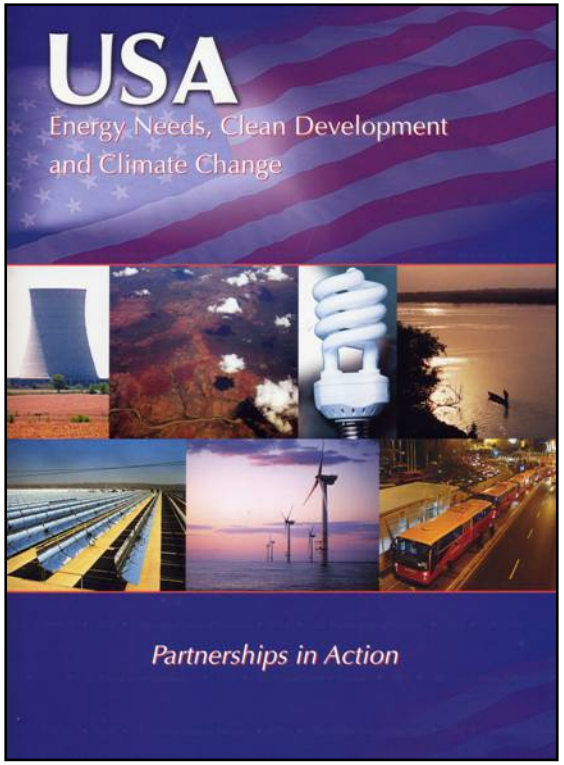
Federal Agency Participation in CCTP

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.**

Near-Term Actions . . .

- **Voluntary Programs**
  - **Climate VISION**
  - **Climate Leaders**
  - **SmartWay Transport Partnership**
  - **Voluntary Reporting of Emissions Reductions, EPACT 1605(b)**
  - **Lighting Programs**
- **Incentives for Investment**
  - **Tax incentives for Renewable Energy, Hybrids, Deployment Partnerships**
  - **USDA Incentives for Sequestration**
  - **USAID and Global Environmental Fund**
  - **Tropical Forest Conservation**
- **Regulatory Reforms**
  - **CAFE Increased for Light Trucks**
  - **Expanded Appliance Standards**



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

Climate VISION Sectors

- Alliance of Automobile Manufacturers
- Aluminum Association
- American Chemistry Council
- American Forest & Paper Association
- American Iron & Steel Institute
- American Petroleum Institute
- Association of American Railroads
- The Business Roundtable
- Industrial Minerals Association - North America
- International Magnesium Association
- National Lime Association
- National Mining Association
- Portland Cement Association
- Power Partners
- Semiconductor Industry Association

Financial Incentives for Investment . . .

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

* Congressional Research Service Analysis of Tax Expenditures for 2003

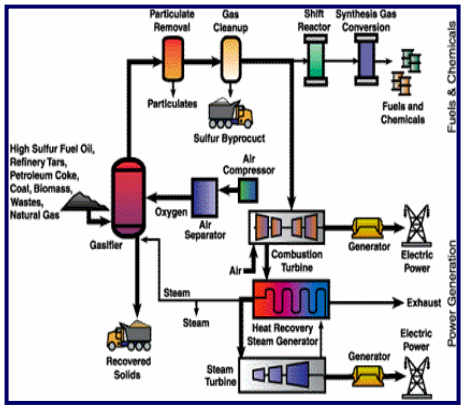
** Fed. Climate Change Expenditures Report, FY 2004

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

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

Loan Guarantees for Clean Energy (*EPAct 2005*)

- **Title XVII Authorizes DOE to Issue Loan Guarantees of up to 80% of Project Costs to Accelerate Commercial Deployment of Advanced Energy Technologies.**
  - **Eligible Technologies Must:**
    - » **Avoid, Reduce or Sequester GHG or Air Pollutants**
    - » **Employ New or Significantly Improved Technology**
  - **Technology Categories Include:**
    - » **Renewables**
    - » **Carbon Capture & Storage**
    - » **Hydrogen Fuel Cells**
    - » **Advanced Nuclear Energy**
    - » **Coal Gasification**
    - » **Energy Efficiency**
    - » **Efficient Generation and T&D**
    - » **Production Facilities for Fuel Efficient Vehicles**
  - **Other Categories Are Potentially Eligible**

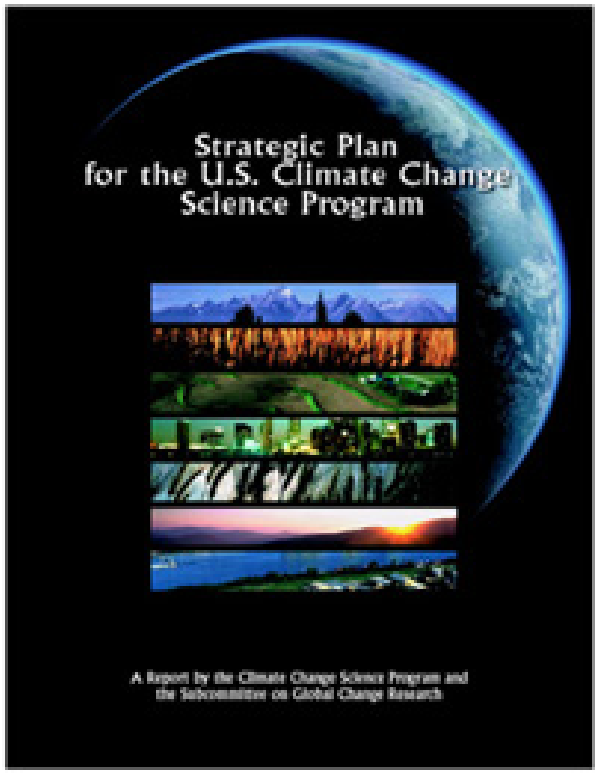


Gasifier

Leadership in Climate Change Science and Technology

Science -- Seeking Better Knowledge and Understanding . . . To Inform Policy

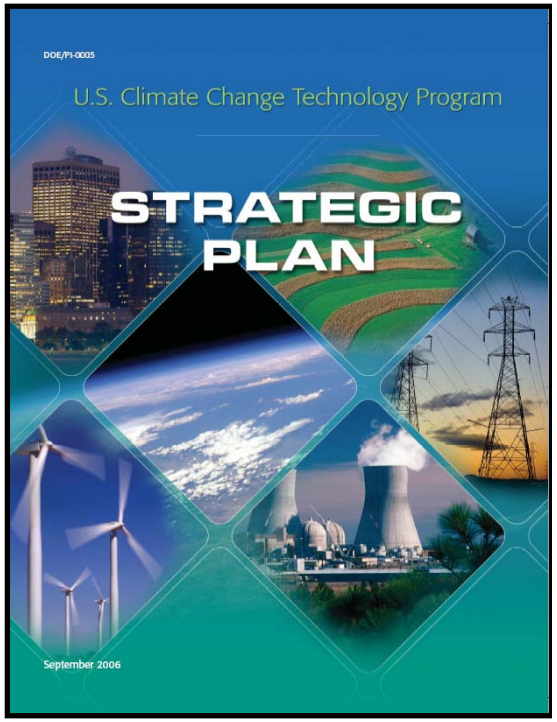
- U.S. Climate Change Science Program
  - An Ambitious Program of Research
  - $2 Billion / Year
- Climate Science Goals
  1. Improve Knowledge of Climate and Environment
  2. Improve Quantification of Forces Driving Changes to Climate
  3. Reduce Uncertainty in Projections of Future Climate Changes
  4. Understand Sensitivity and Adaptability of Natural and Manmade Ecosystems
  5. Explore Uses and Limits of Managing Risks and Opportunities



www.climatescience.gov

Technology: Seeking Better and More Cost-Effective Solutions

- **U.S. Climate Change Technology Program**
  - **An Ambitious Program of RDD&D**
  - **$3 Billion/Year**
- **Climate Technology Goals:**
  1. **Reduce Emissions From Energy End Use & Infrastructure**
  2. **Reduce Emissions From Energy Supply**
  3. **Capture & Sequester CO_2**
  4. **Reduce Emissions From Non-CO_2 Gases**
  5. **Improve Capabilities to Measure & Monitor GHG**
  6. **Bolster Basic Science**
- **CCTP authorized in EPAct 2005.**



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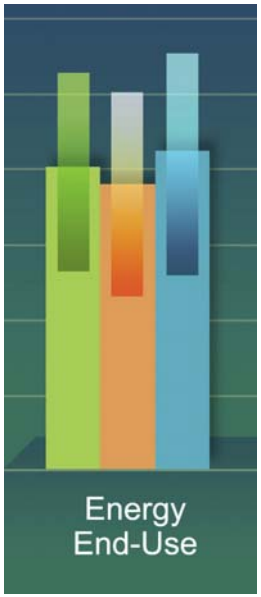
CCTP Goal #1: Reduce Emissions from Energy End-Use and Infrastructure



100-Year Challenge
Up to 270 GTCE

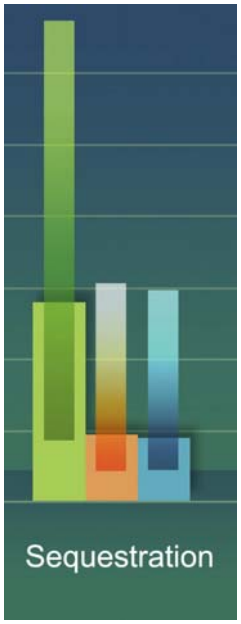
- **Technology Thrusts to Achieve Goal:**
  - **Transportation**
    - ✓ Light & Heavy Vehicles, Intelligent Systems, Aviation, Buses, Fuels
  - **Buildings**
    - ✓ Envelope, Equipment, Whole Building Integration
  - **Industry**
    - ✓ Energy Conversion & Use, Processes, Enabling Technologies, Resource Recovery
  - **Electric Grid and Infrastructure**
    - ✓ Superconductivity, T&D, Storage, Sensors & Controls, Power Electronics

CCTP Goal #2: Reduce Emissions from Energy Supply

- **Technology Thrusts to Achieve Goal:**
  - **Low-Emission Fossil-Based Fuels & Power**
  - **Hydrogen, Bio-Based, and Low Carbon Fuels**
    - ✓ **Production, Storage, Use, Infrastructure, Safety**
  - **Renewable Energy**
    - ✓ **Wind, Solar, Biomass, Hydro, Geothermal**
  - **Nuclear Fission**
    - ✓ **Near-Term Deployment, Next Generation Fission, Advanced Fuel Cycles**
  - **Fusion or Other Novel Sources**
    - ✓ **ITER, Bio-X**

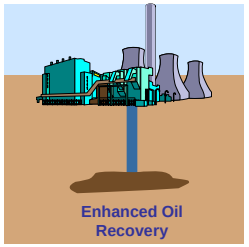
100-Year Challenge
Up to 330 GTCE

CCTP Goal #3: Capture and Sequester Carbon Dioxide



100-Year Challenge
Up to 340 GTCE

- **Technology Thrusts to Achieve Goal:**
  - **CO_2 Capture**
    - ✓ **Capture of CO_2 From Large Point Sources**
  - **Geologic Storage**
    - ✓ **Permanent Storage in Geologic Formations**
  - **Terrestrial Sequestration**
    - ✓ **Land-Based, Biological Sequestration (Trees, Soils, or Other Organic Materials)**
  - **Ocean Sequestration**
    - ✓ **Ocean Sequestration May Play a Role as Science Advances and Potential Effects Understood**



CCTP Goal #4: Reduce Emission of Non-CO_2 Greenhouse Gases

100-Year Challenge
Up to 170 GTCE

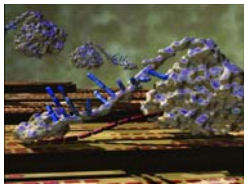
- **Technology Thrusts to Achieve Goal:**
  - **Methane Collection and Use**
  - **Reducing N_2O and Methane Emissions from Agriculture**
  - **Reducing Use of High Global Warming Potential Gases**
    - ✓ **Hydrofluorocarbons, perfluorocarbons**
  - **Black Carbon Aerosols**

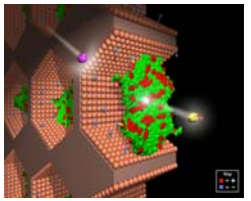
CCTP Goal #5: Improve Capabilities to Measure and Monitor GHG Emissions

- **Technology Thrusts to Achieve Goal:**
  - **Energy Production and Efficiency Measurement**
    - ✓ **Direct and Indirect Measurements From Point and Mobile Sources**
  - **Carbon Capture, Storage & Sequestration**
    - ✓ **Assess Integrity of Subsurface Reservoirs**
  - **Measurement of Non-CO_2 Gases**
  - **Integrated Measuring & Monitoring System Architecture**
    - ✓ **Collect, Analyze and Integrate Data**

CCTP Goal #6: Bolster Basic Science Contributions to Technology Development

- **Basic Research Fundamental To Technology Development:**
  - **Fundamental Research**
    - ✓ **Provides Underlying Foundation of Scientific Knowledge**
  - **Strategic Research**
    - ✓ **Needed to Support a Broad Range of Applied Technology R&D**
  - **Exploratory Research**
    - ✓ **Basic Exploratory Research of Innovative or Novel Concepts to Produce "Breakthrough Technologies"**





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)

Key Technology Initiatives

- Biorefinery Initiative
- Carbon Dioxide Capture and Sequestration
  - CO_2 Capture and Sequestration
  - Carbon Sequestration Regional Partnerships
  - Carbon Sequestration Leadership Forum
- Clean Energy from Wind
- Coal Research Initiative
  - Clean Coal Power Initiative
  - FutureGen
- Generation IV Nuclear Energy Systems Initiative
- Global Nuclear Energy Partnership
- Hydrogen
  - Hydrogen Fuel Initiative
  - FreedomCAR
  - International Partnership for the Hydrogen Economy
- ITER
- Methane to Markets Partnership
- More Efficient Vehicles
- Solar America Initiative

INTERNATIONAL TECHNOLOGY R&D AND DEPLOYMENT PARTNERSHIPS

Innovative International Partnerships

Carbon Sequestration Leadership Forum: 22 members; focused on CO_2 capture & storage. *

International Partnership for the Hydrogen Economy: 17 members; organizes, coordinates, and leverages hydrogen RD&D programs. *

Generation IV International Forum: 10 members; devoted to R&D on next generation of nuclear systems.

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

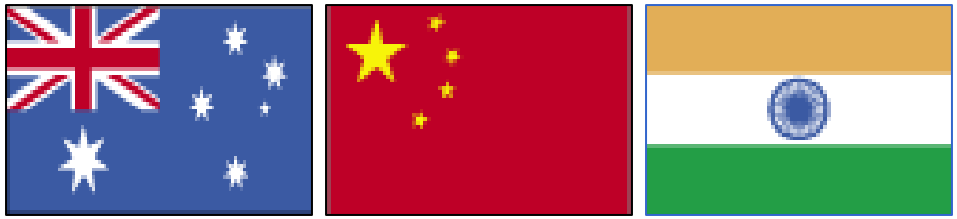
Methane to Markets: 17 members; recovery and use of methane from landfills, mines, oil & gas systems, and agriculture. *

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

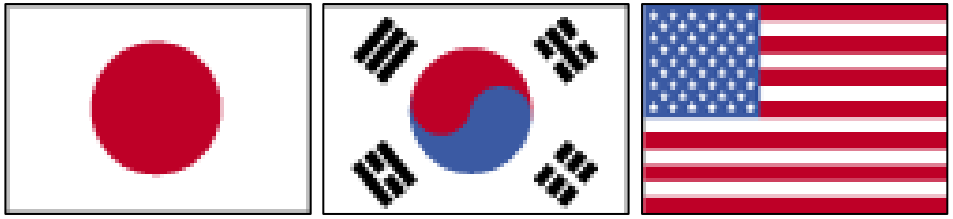
Global Bioenergy Partnership: An Italian G8 initiative to support wider, cost effective, biomass and biofuels deployment, particularly in developing countries. *

Global Nuclear Energy Partnership: A U.S. initiative that seeks to develop worldwide consensus on enabling expanded use of economical, carbon-free nuclear energy to meet growing electricity demand, using a nuclear fuel cycle that enhances energy security and promotes non-proliferation.

Asia-Pacific Partnership on Clean Development and Climate

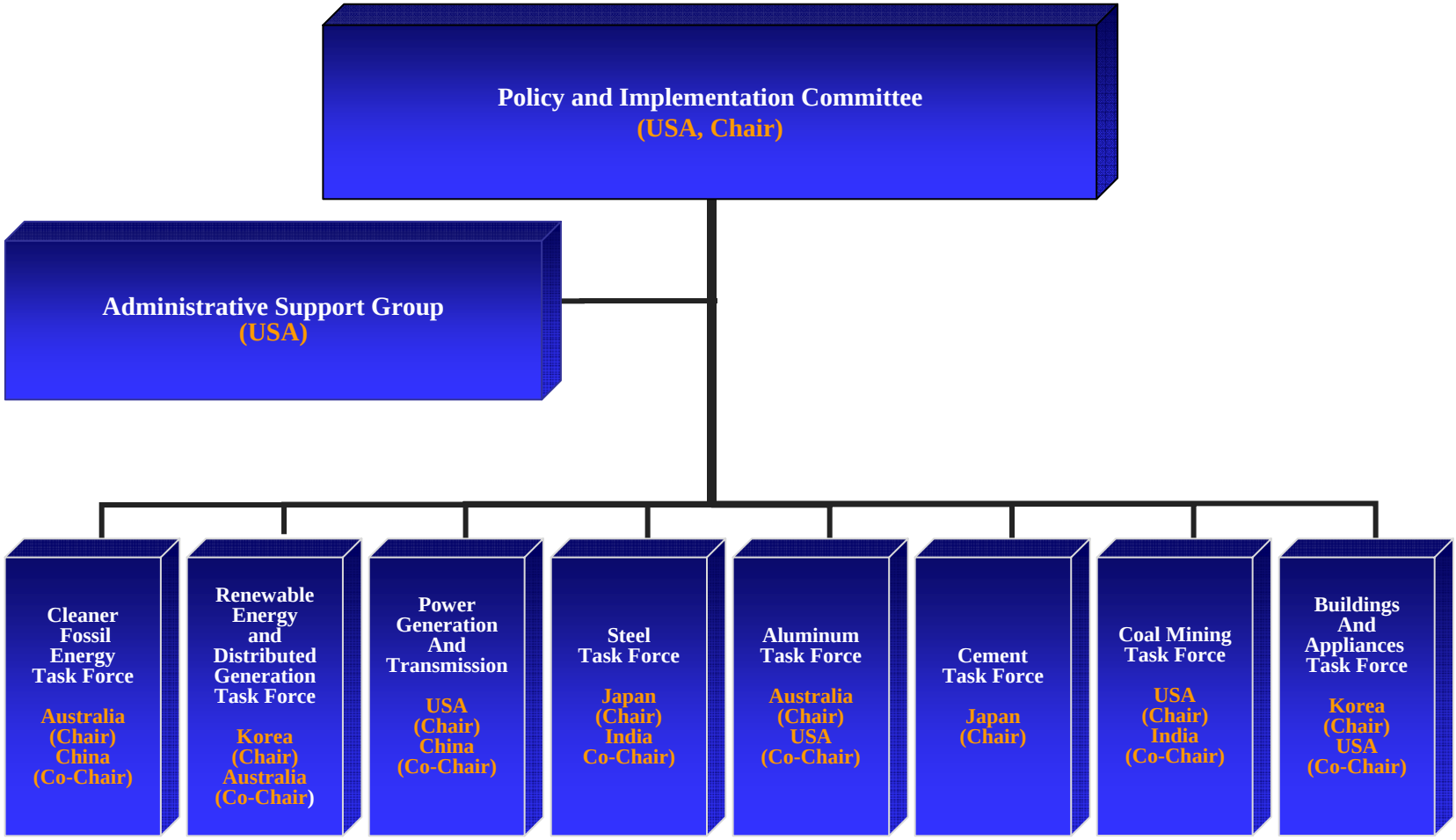


Australia China India



Japan Republic of Korea United States

APP Organizational Chart

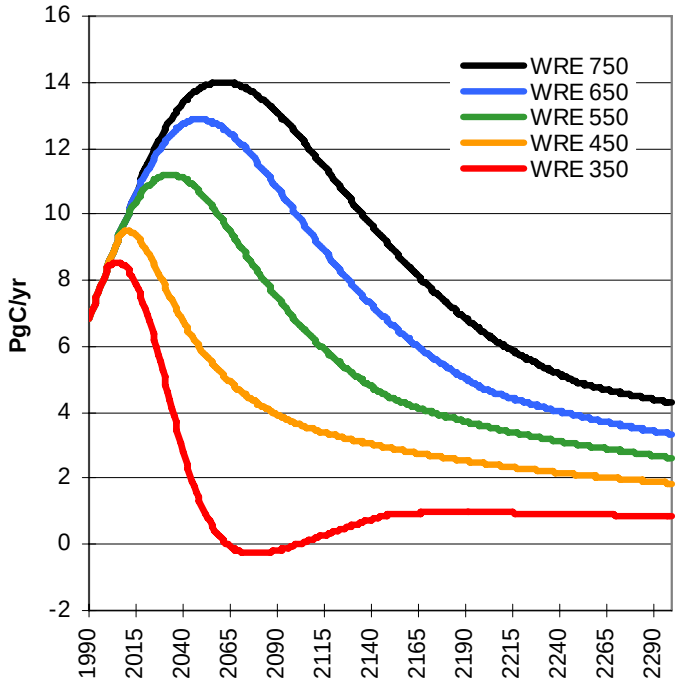


U.S. Climate Change Bilaterals

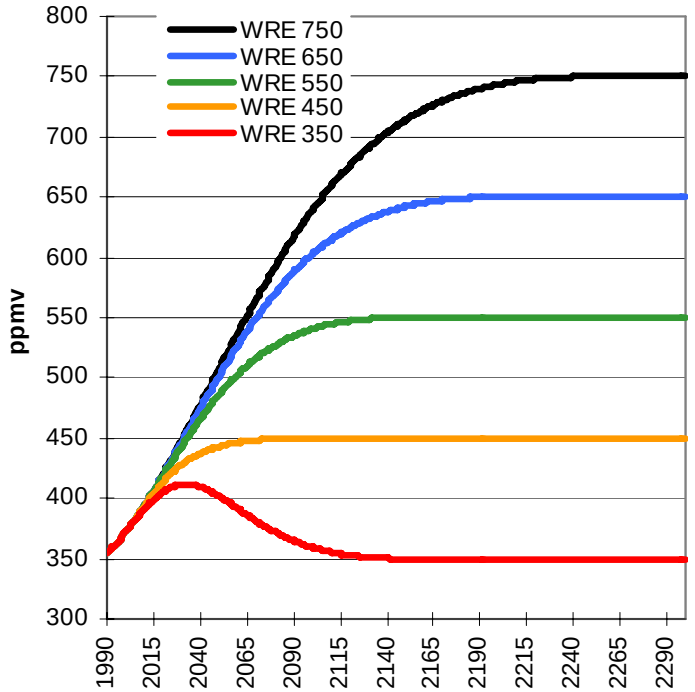
Integrated Results

Planning Under Uncertainty – Alt. Paths to the UNFCCC Goal …

Emission Trajectories

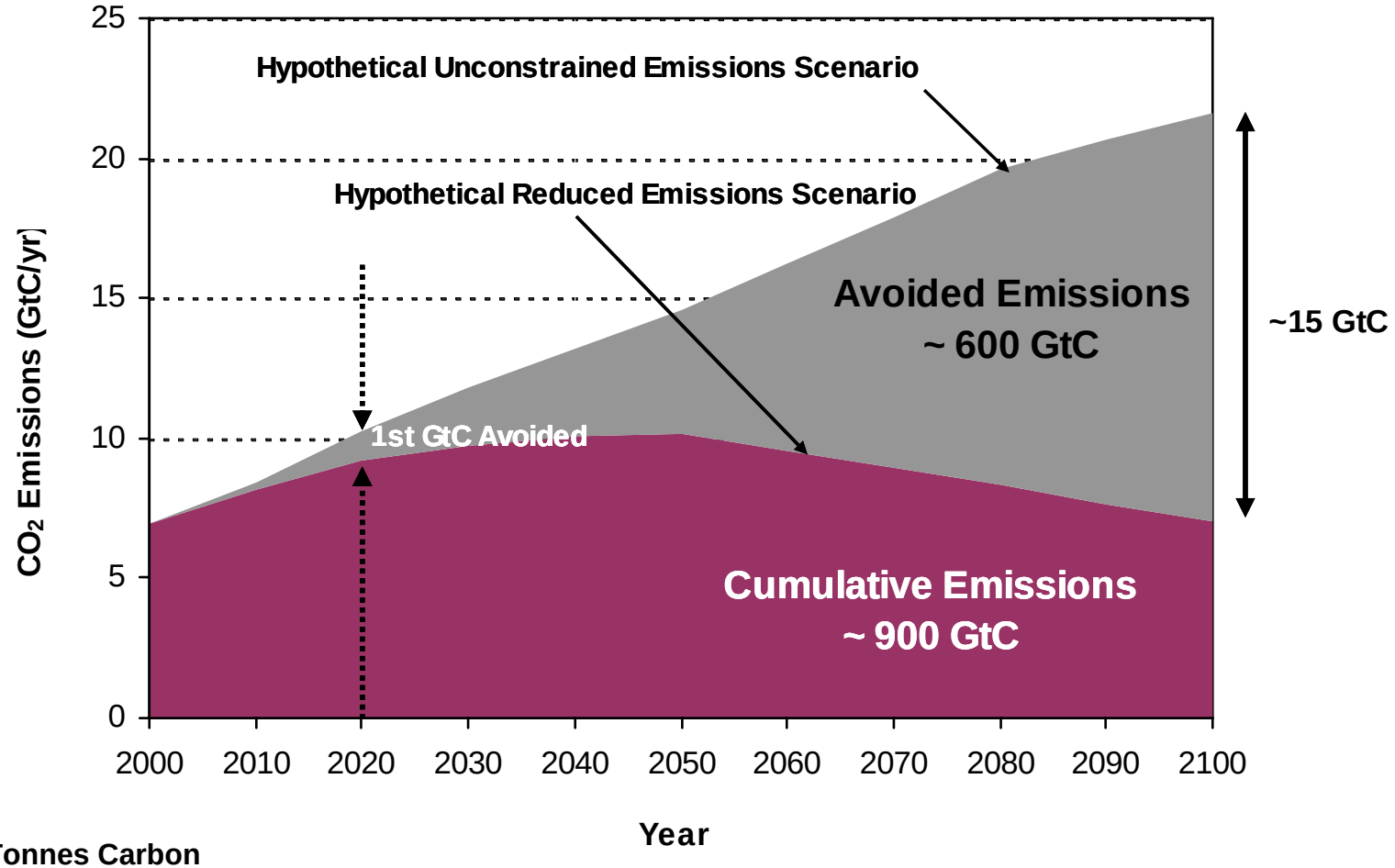


Concentration Trajectories



T.M.L. Wigley, R. Richels, & J.A. Edmonds (WRE), Nature, January 18, 1996, "Economic and Environmental Stabilization of Atmospheric Concentrations"

Mid-Range Example of A Reduced GHG Emissions Future



GtC = Giga-Tonnes Carbon

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

Today's Technology	Actions that Provide 1 Gigaton / Year of Mitigation
Efficiency	Deploy 1 billion new cars at 40 miles per gallon (mpg) instead of 20 mpg
Wind Energy	Install capacity to produce 50 times the current global wind generation (in lieu of coal-fired power plants without CO_2 capture and storage)
Solar Photovoltaics	Install capacity to produce 1,000 times the current global solar PV generation (in lieu of coal-fired power plants without CO_2 capture and storage)
Biomass fuels from plantations	Convert a barren area about 4X the size of France (about 550,000 km^2) to biomass crop production
CO_2 Storage in New Forest.	Convert a barren area about 10X the size of France to new forest
Coal-Fired Power Plants	Build 1,000 "zero-emission" 500-MW coal-fired power plants (in lieu of coal-fired plants without CO_2 capture and storage)
Geologic Sequestration	Install 3,700 sequestration sites like Norway's Sliepner project (0.27 MtC/year)
Nuclear	Build 500 new nuclear power plants, each 1 GW in size (in lieu of new coal-fired power plants without CO_2 capture and storage)

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

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

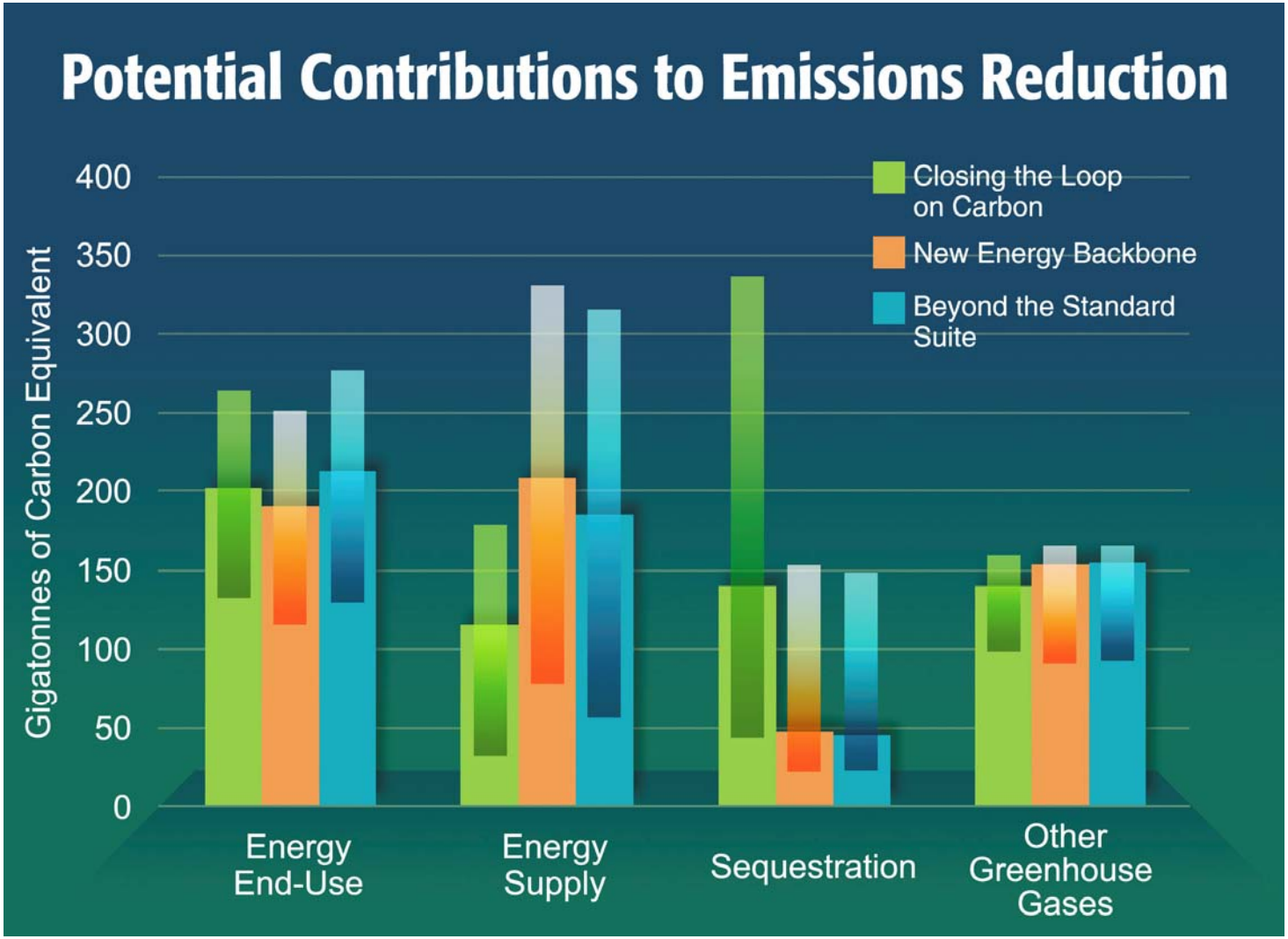
Technology Scenario #3: "Beyond the Standard Suite"

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*

Integrated Results



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

Timing

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

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

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

Quantities – Potential 100-Year Reductions

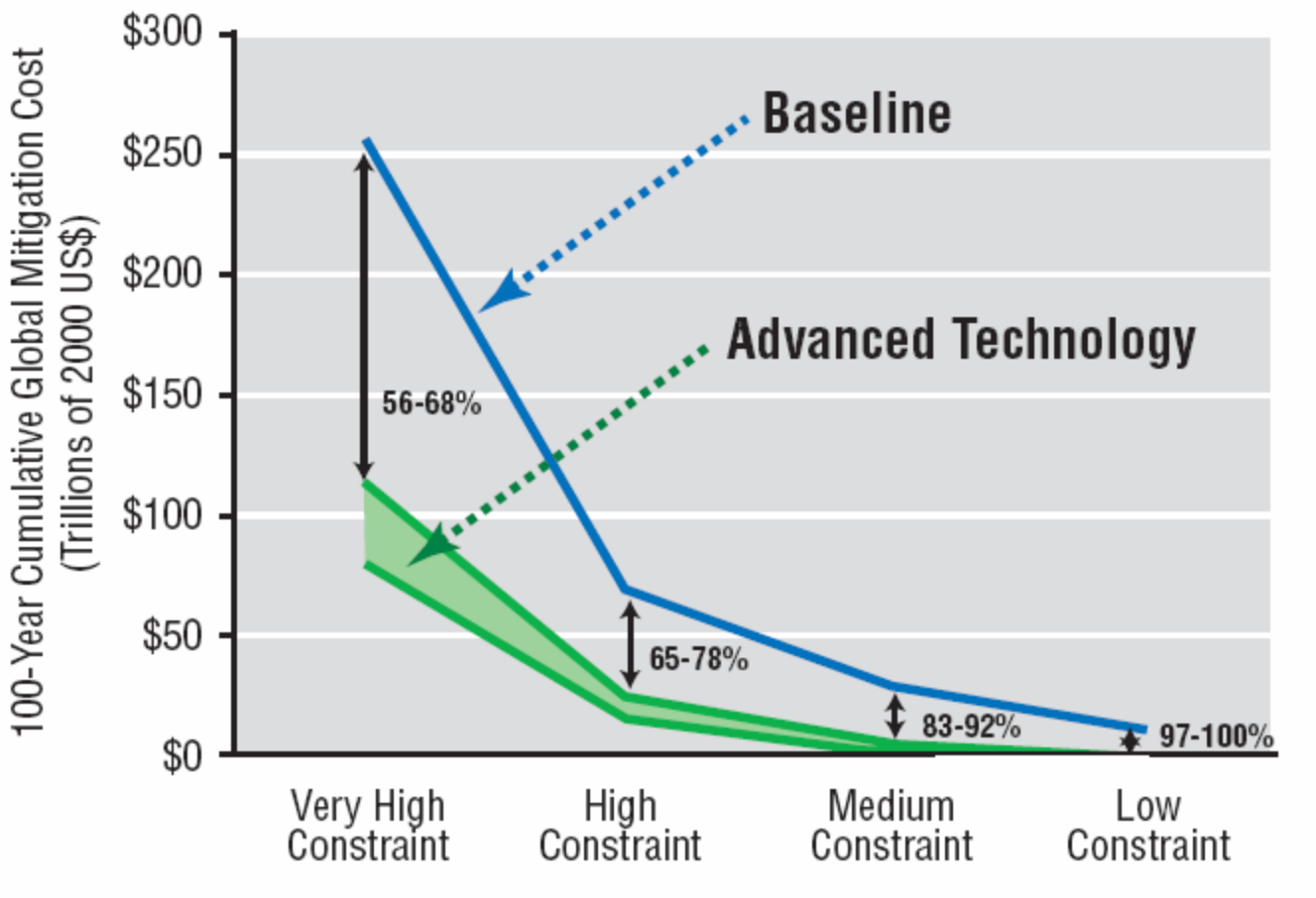
CCTP Strategic Goal	Very High Constraint	High Constraint	Medium Constraint	Low Constraint
Goal #1: Reduce Emissions from Energy End Use and Infrastructure	250 - 270	190 - 210	150 - 170	110 - 140
Goal #2: Reduce Emissions from Energy Supply	180 - 330	110 - 210	80 - 140	30 - 80
Goal #3: Capture and Sequester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

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

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

Cost – Potential 100-Year Reductions

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



Summary -- A Path Forward Involves …

- A Visionary Long-Term Approach, Based on Innovation, Growth and International Cooperation
- Continued Leadership from the Top
- Near-Term Actions – Voluntary, Augmented by Financial Incentives
- Progress in Climate Change Science Will:
  - Reduce Uncertainty and Illuminate Risks and Benefits
  - Add Relevance and Specificity to Assist Decision-Makers
- Progress in Climate Change Technology Will:
  - Create New, Better, and More Affordable Solutions
  - Facilitate Means for Change and Smooth Transition
- Expanded Opportunities for Cooperation Among:
  - Business, Industry, States and NGOs
  - Research Institutions and Academia
  - Cooperative Frameworks with S&T Actions Abroad
- Will Build a Bridge to Low-Emissions Future with Broad Support