

U.S. Climate Change Technology Program

STRATEGIC PLAN

September 2006

To the Reader:



We are pleased to be able to present this *Strategic Plan* for the Climate Change Technology Program (CCTP). The technology strategy detailed in this *Plan* is an essential element of a comprehensive climate change strategy that includes undertaking short-term actions to reduce greenhouse gas emissions intensity, advancing climate science, and promoting international cooperation.

CCTP was created by the President in 2002—and subsequently authorized in the Energy Policy Act of 2005—to coordinate and prioritize the Federal Government’s portfolio of investments in climate-related technology research, development, demonstration, and deployment (RDD&D). The portfolio totaled about \$3 billion in Fiscal Year 2006.

The *Plan* expands on the themes presented in CCTP’s *Vision and Framework for Strategy and Planning*. It provides the underpinnings for a robust RDD&D effort that can make advanced technologies available sooner and at a lower cost. It takes a century-long look at the nature of the climate change challenge and the potential for technological solutions across a range of uncertainties. Most anthropogenic greenhouse gases emitted over the course of the 21st century will come from equipment and infrastructure not yet built, a circumstance that poses significant opportunities to reduce or eliminate these emissions. The technologies outlined in this *Plan*—hydrogen, biorefining, clean coal, carbon sequestration, nuclear fission and fusion, advanced concepts in buildings, industry, transportation and electric energy storage and distribution, and others—have the potential to transform our economy in fundamental ways that can address not just climate change, but energy security, air quality, and other pressing needs.

The *Plan* articulates a vision of the role for advanced technologies, defines a supporting mission for the CCTP, establishes guiding principles for Federal R&D agencies to use in formulating R&D portfolios, outlines approaches to attain CCTP’s strategic goals, and identifies a series of next steps toward implementation. We believe this *Plan* will strengthen the U.S. research enterprise and stimulate U.S. innovation and advance technology development in myriad ways. It is our hope that this *Plan* will inspire similar initiatives in other nations and enhance international collaboration on development and deployment of these technologies.

This document is the outcome of a long process involving governmental working groups, expert review, and a public comment period that stimulated thoughtful and energetic dialogue. It is our hope that with publication of the *Plan*, this dialogue will continue to inform and improve the Program.

The United States is working to ensure a bright and secure energy and economic future for our Nation and a healthy planet for future generations. Through a combination of near-term actions, enhanced scientific understanding of climate change, advanced technology development, and international cooperation, this future can become a reality.

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Foreword

In February 2002, President George W. Bush reorganized the overarching management structure that coordinates and directs U.S. climate change research and development activities. Under this new structure, climate change science and climate-related technology research programs are integrated to an extent not seen previously. The Climate Change Science Program (CCSP), led by the Department of Commerce, was established to reduce the uncertainties in climate science and develop science-based resources to support decision makers. The Climate Change Technology Program (CCTP), the counterpart organization to CCSP, led by the Department of Energy, was formed to coordinate the Federal Government's portfolio of climate-related technology research and development activities, including technology deployment and adoption activities, which were supported by nearly \$3 billion in Fiscal Year 2006, and to focus efforts on the subset of priority activities that are part of the President's National Climate Change Technology Initiative.

The CCTP's *Research and Current Activities* and *Technology Options for the Near and Long Term* reports provided detailed looks at, and introduced the public to, an array of technologies with the potential to reduce greenhouse gas emissions. Our goal with this *Strategic Plan* is to provide a long-term planning context, taking into account the many uncertainties, in which the nature of both the challenges and the opportunities for advanced technologies are illuminated and balanced. Along with its short companion document, CCTP's *Vision and Framework for Strategy and Planning*, the *Plan* provides an inspiring vision of what may be possible and a basis for setting priorities for research through its technology strategies and investment criteria. It also highlights those opportunities that are ripe for advancement.

The *Plan* was guided by the leadership of the Cabinet-level Committee on Climate Change Science and Technology Integration and its Interagency Working Group of agency deputies. It was prepared by an interagency team of six working groups, under the direction of CCTP Deputy Director Dr. Robert C. Marlay. Experts from many different disciplines have made significant contributions to the *Plan*. Without their efforts, this document would not have been possible.

Further, the *Plan* has benefited greatly from hundreds of comments received during the public comment period following release of the draft *Plan* in September 2005. We have been gratified by the quantity and quality of the comments we received, which reflect the importance of the Program. We were able to accommodate most comments, but even those we did not accept challenged our thinking and made the *Plan* stronger. We thank all of those individuals and groups who took time to make comments. As the *Plan* is forward-looking, we expect that public input will be an aspect of future updates to the *Plan*.



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Strategic Plan

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ACRONYMS AND ABBREVIATIONS

ABR	Advanced Burner Reactor	CCCSTI	Committee on Climate Change Science and Technology Integration
AFCI	Advanced Fuel Cycle Initiative	CCP	Carbon Capture Project
AFV	Alternative Fuel Vehicles	CCS	Carbon Capture and Sequestration
AGAGE	Advanced Global Atmospheric Gases Experiment	CCSP	U.S. Climate Change Science Program
ANL	Argonne National Laboratory	CCTP	U.S. Climate Change Technology Program
APS	Aerosol Polarimetry Sensor	CDIAC	Carbon Dioxide Information Analysis Centre
AUV	Autonomous Underwater Vehicles	CEM	Continuous Emissions Monitor
BC	Black Carbon	CETC	Natural Resources Canada CANMET Energy Technology Center
BES	Office of Basic Energy Sciences, U.S. Department of Energy	CEQ	Council on Environmental Quality
BESAC	Basic Energy Sciences Advisory Committee	CFC	Chlorofluorocarbon
BP	British Petroleum	CH₄	Methane
Btu	British Thermal Unit	CHP	Combined Heat and Power (system)
		CMM	Coal Mine Methane

CMOP	Coalbed Methane Outreach Program	GtC-eq.	Gigatonnes (10 ⁹ tonnes or metric tons) of Carbon Equivalent (emissions)
CO₂	Carbon Dioxide	GWP	Global Warming Potential
COL	Construction and Operating License	H₂	Molecular Hydrogen
CSLF	Carbon Sequestration Leadership Forum	H₂S	Hydrogen Sulfide
CSP	Competitive Solicitation Program	HAP	Hazardous Air Pollutants
CSRP	Carbon Sequestration Regional Partnerships	HCFC	Hydrochlorofluorocarbon (refrigerant)
CT	Computed Tomography	HFC	Hydrofluorocarbon
CVD	Chemical Vapor Deposition	HHS	U.S. Department of Health and Human Services
DAI	Dangerous Anthropogenic Interference	HNLC	High Nutrient, Low Chlorophyll
DG	Distributed Generation	HSHL	High Spectral Resolution LIDAR
DOC	U.S. Department of Commerce	HTS	High-Temperature Superconductivity (e.g. wire)
DoD	U.S. Department of Defense	HVACR	Heating, Ventilation, Air Conditioning, and Refrigeration
DOE	U.S. Department of Energy	HVDC	High Voltage Direct Current
DOI	U.S. Department of the Interior	IAEA	International Atomic Energy Agency
DOS	U.S. Department of State	ICF	Inertial Confinement Fusion
DOT	U.S. Department of Transportation	IEA	International Energy Agency
DPC	Domestic Policy Council	IEOS	Integrated Earth Observation System
ECBM	Enhanced Coal-Bed Methane	IFE	Inertial Fusion Energy
EIA	Energy Information Administration	IGCC	Integrated Gasification Combined Cycle
EJ	Exajoule (10 ¹⁸ Joules)	IMSS	Image Multi-Spectral Sensor
EMF	Energy Modeling Forum, Stanford University	IPCC	Intergovernmental Panel on Climate Change
EOR	Enhanced Oil Recovery	IPHE	International Partnership for the Hydrogen Economy
EPA	U.S. Environmental Protection Agency	ITER	International Thermonuclear Experimental Reactor (Latin for “the way”)
ESP	Early Site Permit	ITS	Intelligent Transportation Systems
Euratom	European Atomic Energy Community	IWG	Interagency Working Group
EU	European Union	kg	Kilogram
FACE	Free-Air CO ₂ Enrichment	kW	Kilowatt
FACTS	Flexible Automated Control Transmission Systems	kWe	Kilowatt (electric)
FC	Fuel Cell	kWh	Kilowatt-hour
FCT	Fuel Cell Turbine	LANL	Los Alamos National Laboratory
FES	Fusion Energy Sciences, U.S. Department of Energy, Office of Science	LCCP	Life-Cycle Climate Performance
FFRDC	Federally Funded Research and Development Center	LED	Light-Emitting Diode
FHA	Federal Highway Administration	LFG	Landfill Gas
FTC	Federal Trade Commission	LH₂	Liquefied Hydrogen
FTIR	Fourier Transform Infrared Spectroscopy	LIBS	Laser Induced Breakdown Spectroscopy
FY	Fiscal Year	LIDAR	Light Detection and Ranging
GDP	Gross Domestic Product	LNLC	Low Nutrient, Low Chlorophyll
Gen IV	Generation IV	MEA	Monoethanolamine
GEO	Group on Earth Observations	MFE	Magnetic Fusion Energy
GEO-SEQ	Geological Sequestration (project)	MiniCAM	Mini Climate Assessment Model (Pacific Northwest National Laboratory)
GEOSS	Global Earth Observation System of Systems	MM	Measuring and Monitoring
GHG	Greenhouse Gas	MOF	Microporous Metal Organic Frameworks
GIF	Generation IV International Forum (nuclear power)	mpg	miles per gallon
GOSAT	Greenhouse Gas Observing SATellite	mph	miles per hour
Gt	Gigatonnes (10 ⁹ tonnes or metric tons)		
GtC	Gigatonnes (10 ⁹ tonnes or metric tons) of Carbon		

MSPI	Multi-angle SpectroPolarimetric Imager	Quad	Quadrillion Btus (10^{15} Btus)
MtC	Megatonnes Carbon	R&D	Research and Development. Also used generically to mean RD&D and RDD&D
MWe	Megawatt electric	RD&D	Research, Development, and Demonstration
N₂O	Nitrous Oxide	RDD&D	Research, Development, Demonstration, & Deployment
NACP	North American Carbon Program	RFI	Request for Information
NAE	National Academy of Engineering	SCR	Selective Catalytic Reduction
NAS	National Academy of Sciences	SF₆	Sulfur Hexafluoride
NASA	National Aeronautics and Space Administration	SNAP	Significant New Alternatives Program
NEC	National Economic Council	SOFeX	Southern Ocean Iron Fertilization Experiment
NEPO	Nuclear Energy Plant Optimization (Program)	SOIREE	Southern Ocean Iron Enrichment Experiment
NCCTI	National Climate Change Technology Initiative	SO_x	Sulfur Oxides
NERAC	Nuclear Energy Research Advisory Committee	SQUIDS	Superconducting Quantum Interference Devices
NETL	National Energy Technology Laboratory	SRES	Special Report on Emissions Scenarios (of the IPCC)
NH₃	Ammonia	T&D	Transmission and Distribution
NIF	National Ignition Facility	TgC	Teragrams of Carbon
NNSA	National Nuclear Security Administration, U.S Department of Energy	Tg CO₂	Teragrams Carbon Dioxide
NO_x	Nitrogen Oxides	Tg CO₂-eq.	Teragrams Carbon Dioxide Equivalent (emissions)
NOAA	National Oceanic and Atmospheric Administration	UN	United Nations
NRC	National Research Council or Nuclear Regulatory Commission	UNDP	United Nations Development Program
NRCan	Natural Resources Canada	UNEP	United Nations Environmental Program
NREL	National Renewable Energy Laboratory	UNFCCC	United Nations Framework Convention on Climate Change
NSC	National Security Council	USAID	U.S. Agency for International Development
NSCR	Non-Selective Catalytic Reduction	USDA	U.S. Department of Agriculture
NSF	National Science Foundation	USGEO	United States Group on Earth Observation
NSTX	National Spherical Torus Experiment	VAM	Ventilation Air Methane
NVFEL	National Vehicle and Fuels Emission Laboratory	VOC	Volatile Organic Compounds
OC	Organic Carbon	W/m²	Watts per Square Meter
OCO	Orbiting Carbon Observatory	WCRP	World Climate Research Program
ODS	Ozone-Depleting Substance	WG	Working Group
OMB	Office of Management and Budget	WMO	World Meteorological Organization
ONR	Office of Naval Research	WOCE	World Ocean Circulation Experiment
ORNL	Oak Ridge National Laboratory	WRE	T. Wigley, R. Richels, and J. Edmonds
OSTP	Office of Science and Technology Policy		
PEM	Polymer Electrolyte Membrane		
PFC	Perfluorocarbons		
PM	Particulate Matter		
PNNL	Pacific Northwest National Laboratory		
POU	Point Of Use		
PPPL	Princeton Plasma Physics Laboratory		
PV	Present Value		