

1.0 Introduction

The U. S. Department of Energy's (DOE's or the Department's) hydrogen and fuel cell efforts are part of a broad portfolio of activities to build a competitive and sustainable clean energy economy to secure the nation's energy future. Reducing greenhouse gas emissions 80 percent by 2050¹ and eliminating dependence on imported fuel will require the use of diverse domestic energy sources and advanced fuels and technologies in all sectors of the economy. Achieving these goals requires a robust, comprehensive research and development (R&D) portfolio that balances short-term objectives with long-term needs and sustainability.

Fuel cells, which convert diverse fuels directly into electricity without combustion, and hydrogen, a zero-carbon fuel when produced from renewable resources, comprise key elements of the DOE portfolio. DOE's efforts to enable the widespread commercialization of hydrogen and fuel cell technologies form an integrated program—the DOE Hydrogen and Fuel Cells Program (the Program), as reflected in the Hydrogen and Fuel Cells Program Plan.² The Program is coordinated across the Department and includes activities in the offices of Energy Efficiency and Renewable Energy (EERE), Science, Nuclear Energy, and Fossil Energy.

The Fuel Cell Technologies Program (FCT Program), situated within EERE, addresses key technical challenges for fuel cells and hydrogen production, delivery, and storage and the institutional barriers, such as hydrogen codes and standards, training, and public awareness that inhibit the widespread commercialization of hydrogen and fuel cell technologies. The FCT Program conducts applied research, technology development and learning demonstrations, as well as safety research, systems analysis, early market deployments, and public outreach and education activities. These activities include cost-shared, public-private partnerships to address the high-risk, critical technology barriers preventing extensive use of hydrogen as an energy carrier. Public and private partners include automotive and power equipment manufacturers, energy and chemical companies, electric and natural gas utilities, building designers, standards development organizations, other Federal agencies, state government agencies, universities, national laboratories, and other national and international stakeholder organizations. The FCT Program encourages the formation of collaborative partnerships to conduct research, development and demonstrations (RD&D) and other activities, such as deployment, that support program goals.

The FCT Program addresses the development of hydrogen energy systems for transportation, stationary power, and portable power applications. Transportation applications include fuel cell vehicles (such as buses, automobiles and heavy duty vehicles), niche markets (such as lift trucks), and hydrogen refueling infrastructure. Hydrogen used for back-up emergency power, commercial/industrial power and heat generation, and residential electric power generation is included in stationary power applications. Consumer electronics such as mobile phones, laptop computers, and recharging systems are among the portable power applications. The DOE is funding RD&D efforts that will provide the basis for the near-, mid-, and long-term production, delivery, storage, and use of hydrogen derived from diverse energy sources, including renewable, fossil fuels, and nuclear

¹ The Obama-Biden Plan, available at http://change.gov/agenda/energy_and_environment_agenda/.

² Available at http://www1.eere.energy.gov/hydrogenandfuelcells/program_plans.html.

energy as coordinated within the Program. This document primarily describes the status, challenges, and RD&D activities of the FCT program but also the overall DOE Hydrogen and Fuel Cells Program.

1.1 Background

In the early 1970s, concern over the United States' growing dependence on imported petroleum, coupled with concerns about our deteriorating air quality resulting from combustion of fossil fuels, prompted initial DOE activity supporting hydrogen technology. In the late 1980s, DOE initiated the Fuel Cells for Transportation Program to develop polymer electrolyte membrane fuel cells (PEMFCs) for automotive use. This was followed by subsequent efforts in the 1990s and 2000s resulting in steady progress. The FCT Program utilizes the results of these past efforts and incorporates the direction and guidance of the *DOE Strategic Plan*³, the *U.S.DRIVE Partnership Plan*⁴, the *National Hydrogen Vision*⁵, the *National Hydrogen Energy Roadmap*⁶, the *Energy Policy Act of 2005 (EPACT)*, the *Energy Independence and Security Act of 2007 (EISA)* and the *American Recovery and Reinvestment Act of 2009 (Recovery Act)*. In addition, the FCT Program has incorporated the contributions and ideas of hundreds of experts from U.S. and international industry, government, and academia.

Key Drivers

Three major factors require new approaches to the way the United States produces, delivers, and uses energy. These drivers are as follows:

- Energy security
- Environmental quality
- Economic vitality.

Energy Security

The need to expand the supply of domestically produced energy is significant. America's transportation sector relies almost exclusively on refined petroleum products. Approximately 52% of the petroleum consumed for transportation in the United States is imported,⁷ and that percentage is expected to rise steadily for the foreseeable future (Figure 1.1). On a global scale, petroleum supplies will be in higher demand as highly populated, developing countries expand their economies and become more energy-intensive. Hydrogen-powered fuel cell vehicles would virtually eliminate imports of foreign oil, because the hydrogen fuel can be produced almost entirely from the diverse domestic energy sources of renewable resources, fossil fuels, and nuclear power. Hydrogen's role as a major energy carrier would also provide the United States with a more efficient and diversified

³ Available at http://energy.gov/sites/prod/files/2011_DOE_Strategic_Plan_.pdf

⁴ Available at http://www1.eere.energy.gov/vehiclesandfuels/about/partnerships/roadmaps-other_docs.html.

⁵ Available at http://www1.eere.energy.gov/hydrogenandfuelcells/pdfs/vision_doc.pdf.

⁶ Available at http://www.hydrogen.energy.gov/pdfs/national_h2_roadmap.pdf.

⁷ Sources: Oak Ridge National Laboratory, *Transportation Energy Data Book: Edition 29*, ORNL-6985, July 2010, <http://info.ornl.gov/sites/publications/files/Pub24318.pdf>; Energy Information Administration, *Petroleum Supply Annual 2009*, July 2010, http://205.254.135.24/petroleum/supply/annual/volume1/archive/2009/pdf/volume1_all.pdf.

energy infrastructure that includes a variety of options for fueling central and distributed electric power generation systems.

U.S. Petroleum Consumption

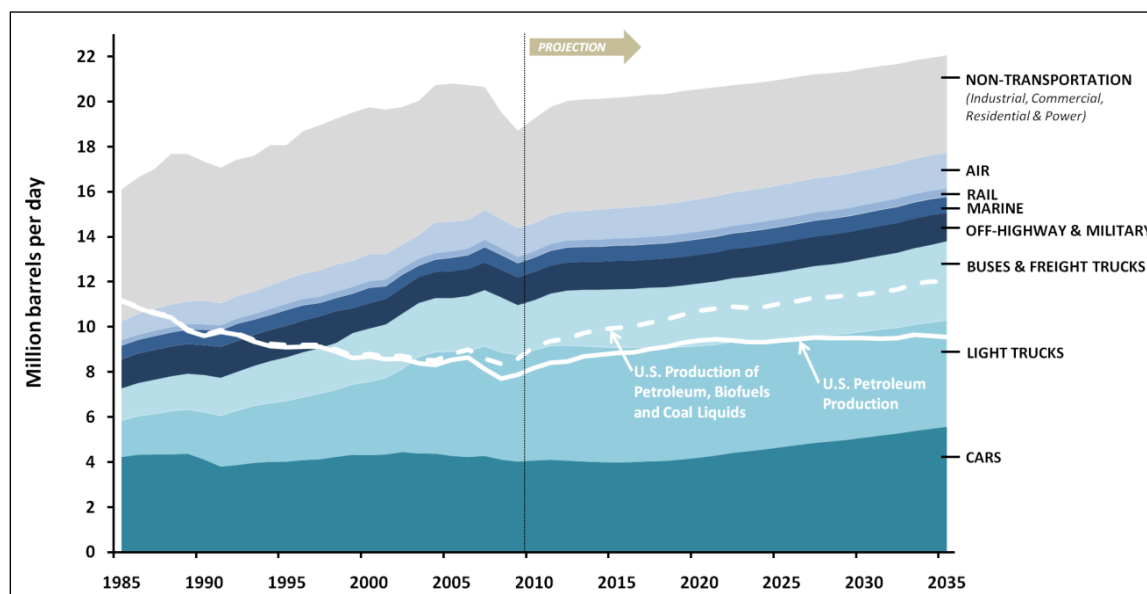


Figure 1.1. America’s Widening “Oil Gap.” America’s reliance on imported oil is the key challenge to our energy security. While oil is used in all sectors and for a wide variety of uses, the large majority is used for transportation—and a majority of that is used in light-duty passenger vehicles (cars and light trucks).⁸

Environmental Quality

The combustion of fossil fuels accounts for the majority of anthropogenic greenhouse gas emissions (chiefly carbon dioxide, CO₂) released into the atmosphere. The largest sources of CO₂ emissions are the electric utility and transportation sectors. Should strong constraints on carbon emissions be required, hydrogen will play an important role in a low-carbon global economy. Distributed hydrogen production from natural gas and central hydrogen production from natural gas (with the potential for capture and sequestration of carbon) and coal (with the capture and sequestration of carbon) can provide the means for domestic fossil fuels to remain viable energy resources. In addition, fuel cells operating on hydrogen produced from renewable resources or nuclear energy result in near-zero carbon emissions.

Air quality is a major national concern. It has been estimated that about 50% of Americans live in areas where levels of one or more air pollutants are high enough to affect public health and/or the environment.⁹ Personal vehicles and electric power plants are significant contributors to the nation’s air quality problems. Most states are now developing strategies for achieving national ambient air

⁸ Sources: Oak Ridge National Laboratory, *Transportation Energy Data Book: Edition 29*, ORNL-6985, July 2010, <http://info.ornl.gov/sites/publications/files/Pub24318.pdf>; Energy Information Administration, *Annual Energy Outlook*, April 2010, [www.eia.doe.gov/oiaf/aeo/pdf/0383\(2010\).pdf](http://www.eia.doe.gov/oiaf/aeo/pdf/0383(2010).pdf)

⁹ DOE Hydrogen Program Record 8013, available at: http://www.hydrogen.energy.gov/pdfs/8013_air_quality_population.pdf

quality goals and bringing their major metropolitan areas into compliance with the requirements of the Clean Air Act. For example, the introduction of commercial bus fleets using hydrogen is one of the approaches that local governments are taking to improve air quality. California, where 90% of the population breathes unhealthy levels of one or more air pollutants during some part of the year, has been one of the most aggressive states in its strategies and has launched a number of programs targeted at improving urban air quality. The Benefits section of this Plan describes the potential impact that fuel cells can have to improve air quality.

Economic Vitality

National economic security seems to be heavily dependent on our energy security. There is also evidence of growing worldwide interest in hydrogen and fuel cell technology, as reflected in the dramatic increase in public and private spending since the mid-1990s. Governments and industries in Canada, Europe, and Asia are investing heavily in hydrogen research, development, and demonstration. In 2001, the Japanese government nearly doubled its fuel cell RD&D budget to \$220 million and launched a joint government/industry demonstration of hydrogen fuel cell vehicles, including the deployment of more than seven new hydrogen refueling stations. The Japanese fuel cell budget has continued to grow and is projected to total about \$1 billion from 2008 through 2012. Japan announced plans for 2 million fuel cell vehicles and 1,000 fueling stations by 2025. As another example, Germany plans to invest \$1 billion from 2007 through 2016 and plans up to 1,000 hydrogen fueling stations throughout the country. Korea is also significantly ramping up its efforts and plans to produce 20% of global fuel cell shipments and create 560,000 jobs in Korea.¹⁰ The U.S. must be a leader in hydrogen and fuel cell technology development and commercialization in order to secure a competitive position for future energy technology innovations, new products, and service offerings.

Challenges for Hydrogen as an Energy Carrier

The transition from our current energy infrastructure to a clean and secure energy infrastructure based on hydrogen and other alternative fuels will take decades as the difficult challenges posed by technological, economic, and institutional barriers are addressed and overcome. For hydrogen, the “critical path” barriers are summarized in the following sections.

¹⁰ Available at http://www1.eere.energy.gov/hydrogenandfuelcells/program_plans.html.

Technology Challenges

- Compact, lightweight, and low-cost storage systems must be developed. For vehicles, technologies must enable greater than 300-mile driving range across all vehicle platforms without reducing performance or interior space.
- The cost of producing and delivering hydrogen from zero or near-zero carbon sources must be reduced. Low-cost and environmentally sound CO₂ capture and sequestration technologies must be developed.
- The cost of fuel cells must be reduced and their durability improved, to be competitive with current technologies.

Economic and Institutional Challenges

- The risk of expanding the hydrogen delivery infrastructure is high, given technology status, but the infrastructure must keep pace with planned fuel cell roll outs in stationary and transportation applications.
- Uniform model codes and standards to ensure safety and insurability are needed.
- Local code officials, policy makers and the general public lack education on hydrogen benefits and on safe handling and use.
- A robust, domestic manufacturing and component supplier base for hydrogen and fuel cell technologies needs to be developed.

1.2 Program Vision and Mission

Today, after decades of dependence on imported petroleum, our nation has a new vision for our energy future: forms of domestically derived, clean energy to power not only our vehicles but our industries, buildings, and homes. In addition to clean coal (with carbon sequestration) and nuclear energy, the energy carriers of the future will include electricity from renewable sources, alternative liquid fuels (e.g., bio-based or renewable fuels), and hydrogen.

In the long-term vision, fuel cells will be available in all regions of the country and will serve all sectors of the economy. Diverse domestically available fuels, such as biogas and natural gas will be used in fuel cells with high efficiency and low emissions. Hydrogen will be produced from renewable resources and fossil fuels (with carbon capture and sequestration), as well as nuclear energy. It will be used in the transportation, electric power, and consumer sectors. Hydrogen will be produced in centralized facilities and in distributed facilities at fueling stations, rural areas, and community locations. Hydrogen production and storage costs will be competitive; the basic components of a national hydrogen delivery and distribution network will be in place; and hydrogen-powered fuel cells, engines, and turbines will have become mature technologies in mass production for diverse applications.

To succeed in achieving this vision, the Program's mission is to enable the widespread commercialization of a portfolio of hydrogen and fuel cell technologies through basic and applied research, technology development and demonstration, and diverse efforts to overcome institutional and market challenges.

1.3 Fuel Cell Technologies Program Key Activities

The FCT Program facilitates the applied research and technology development efforts needed for hydrogen and fuel cell technology readiness. The FCT Program is the lead for directing and integrating RD&D and deployment activities in hydrogen production, storage, delivery and end use for transportation, stationary, and portable applications. Table 1.1 lists the sub-programs of the FCT Program and their focus.

The FCT Program collaborates with industry, academia, and national laboratories, as well as closely coordinates activities with the Vehicle Technologies Program and other DOE programs to achieve EERE's strategic goals relevant to the FCT Program, as follows:

- Dramatically reduce dependence on foreign oil
- Promote the use of diverse, domestic and sustainable energy resources
- Reduce carbon emissions from energy production and consumption
- Increase the reliability and efficiency of electricity generation.

Table 1.1. Sub-Programs of the FCT Program	
Sub-Program	Sub-Program Focus
Production	Clean, cost-effective, and efficient production of hydrogen from renewable, fossil, and nuclear energy resources
Delivery	Low cost, safe distribution of hydrogen from centralized or distributed sites of production
Storage	Materials and systems RD&D for onboard vehicular hydrogen storage that will allow for a driving range of 300 miles or more and for storage for stationary and portable applications.
Fuel Cells	Materials, component, and system RD&D to reduce cost and improve durability of PEM fuel cells for transportation, stationary, and portable applications
Manufacturing	High-volume fabrication and assembly processes to reduce cost and develop a domestic supplier base
Technology Validation	Field tests and evaluation of hydrogen and fuel cell technologies and technical validation of integrated systems in real-world environments
Safety, Codes and Standards	Working to ensure safety in hydrogen production and use by applying lessons learned and best practices within the program and promulgating that experience outside the program. Working with Standards Development Organizations and Code Development Organizations to facilitate the development of hydrogen technology codes and standards. Also supports RD&D that provides a basis for the technical requirements needed for codes and standards.
Education	Educating key target audiences—state and local government stakeholders, early adopters and commercial end users, teachers and students, safety and code officials—about the use of hydrogen and fuel cell technologies in numerous applications.
Systems Analysis	Evaluating existing and emerging technologies through multiple pathways utilizing a fact-based analytical framework to guide the selection and evaluation of RD&D projects and to provide a basis for estimating the potential value of research efforts.
Systems Integration	Understanding the complex interactions between components, systems costs, environmental impacts, societal impacts, and system trade-offs. Identifying and analyzing these interactions will enable evaluation of alternative concepts and pathways and result in well-integrated and optimized hydrogen and fuel-cell systems.
Market Transformation	Stimulating the market and industry by providing financial assistance for demonstrating fuel cells in early-market applications.

These goals can be realized with a domestic hydrogen energy system, and are consistent with broader DOE policy goals. As illustrated in Figure 1.2, diverse fuels can be used in fuel cells, and hydrogen can be produced from a diverse set of domestic resources, including renewable, fossil, and

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nuclear resources, helping to attain the first three strategic goals. High efficiency and low emissions through the use of fuel cells in both transportation and distributed electric power generation support achieving the third and fourth strategic goals.

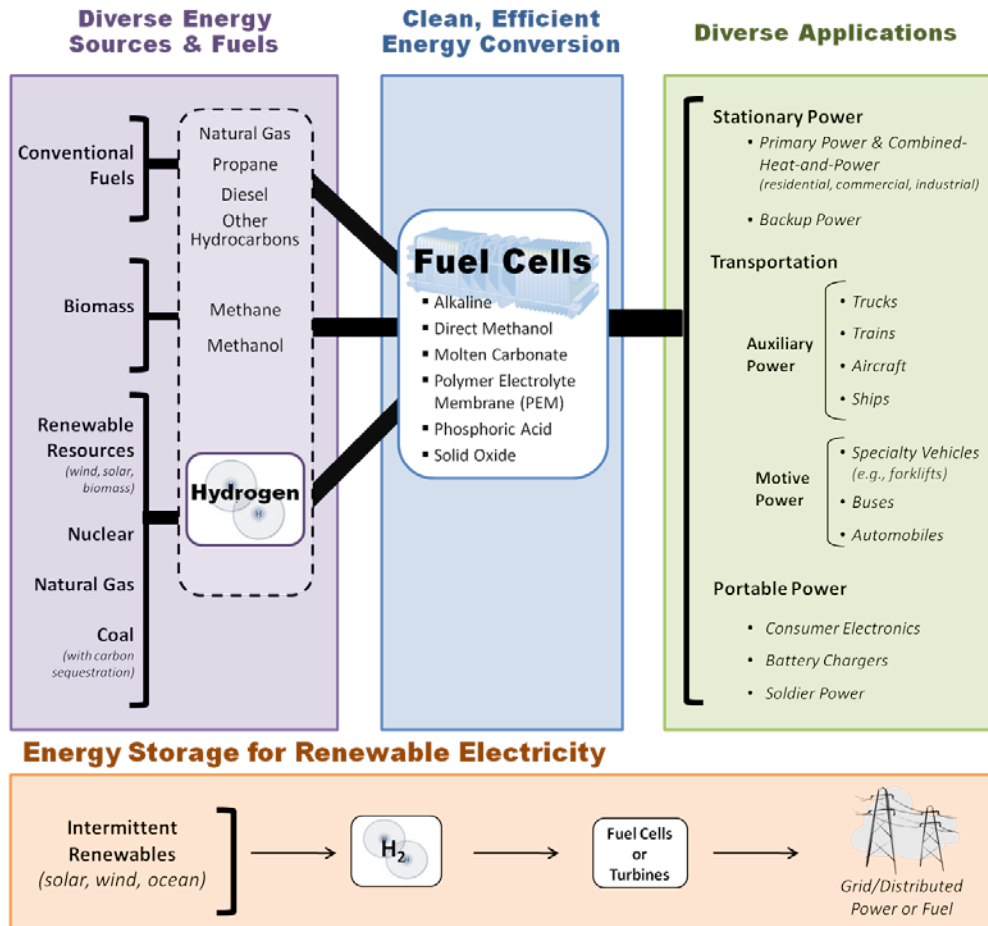


Figure 1.2 Fuel cells and hydrogen can be used for diverse applications.

The FCT Program supports research, development and demonstration activities linked to public-private partnerships. As activities progress through the stages of research and development to validating technical targets, the government’s cost share will diminish. The government’s role as co-funder will promote technology maturation, allowing the private sector to make informed decisions on feasibility and methods of commercializing the technology.

1.4 Program Planning

The FCT Program's Multi-Year RD&D plan is built upon several predecessor planning documents and is integrated with other DOE office plans (Figure 1.3). The Plan also describes the details of research and technology development, requirements, and schedule in support of the *Energy Policy Act of 2005*, the *Energy Independence and Security Act of 2007*, the *National Hydrogen Energy Vision and Roadmap*, *DOE Strategic Plans*, *DOE Hydrogen and Fuel Cells Program Plan*, *DOE Fuel Cell Report to Congress*, and the *U.S. DRIVE Partnership Plan*.

National Hydrogen Energy Vision and Roadmap

In response to recommendations within the *National Energy Policy*, DOE organized a November 2001 meeting of 50 visionary business leaders and policymakers to formulate a National Hydrogen Vision. *A National Vision of America's Transition to a Hydrogen Economy – to 2030 and Beyond* was published in February 2002 as a result of the Hydrogen Vision Meeting. This document summarizes the potential role for hydrogen systems in America's energy future, outlining the shared vision of the market transformation.

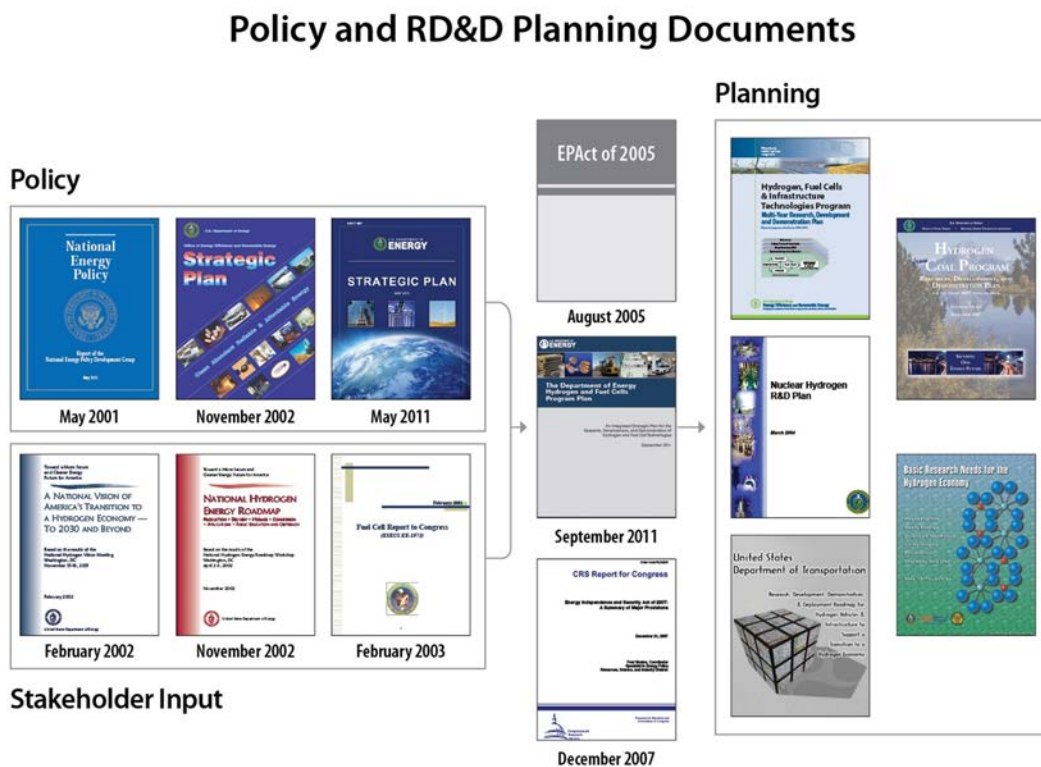


Figure 1.3 Policy and RD&D planning documents

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In April 2002, DOE followed up with a larger group of over 200 technical experts from industry, academia, and the national laboratories to develop a *National Hydrogen Energy Roadmap*. This roadmap, released in November 2002, describes the principal challenges to be overcome and recommends paths forward to achieve the vision.

DOE Strategic Planning

Building on the recommendations of the *National Hydrogen Energy Vision and Roadmap*, DOE's and EERE's strategic plans provide the broad direction under which the Multi-Year RD&D Plan was formulated.

A central goal in the *Department of Energy's Strategic Plan* (May 2011) is to protect our national and economic security by promoting a diverse supply and delivery of reliable, affordable and environmentally sound energy. The Program supports DOE's mission as described in the DOE Strategic Plan, and it addresses three of the Department's four key goals:

Goal 1: Catalyze the timely, material, and efficient transformation of the nation's energy system and secure U.S. leadership in clean energy technologies

Goal 2: Maintain a vibrant U.S. effort in science and engineering as a cornerstone of our economic prosperity with clear leadership in strategic areas

Goal 4: Establish an operational and adaptable framework that combines the best wisdom of all Department stakeholders to maximize mission success

Hydrogen and Fuel Cells Program Plan

In February 2004, DOE published its *Hydrogen Posture Plan*, which describes DOE's "plan for successfully integrating and implementing technology research, development and demonstration activities needed to cost-effectively produce, store and distribute hydrogen for use in fuel cell vehicles and electricity generation." Research, development, and demonstration efforts across the DOE Offices of EERE, Nuclear Energy, Fossil Energy, and Science, and the Department of Transportation are described and are consistent with the recommendations in the *National Hydrogen Energy Roadmap*. The *Hydrogen Posture Plan* is the key supporting document underpinning the DOE Hydrogen and Fuel Cells Program. It was updated in fiscal year 2007 to reflect progress and to address the implications of EPACT 2005 and updated and renamed to the *Hydrogen and Fuel Cells Program Plan* in fiscal year 2011 to reflect progress and to address the implication of EISA 2007 and the Recovery Act of 2009. The revised plan was posted online in 2010 for public comment, and feedback was incorporated both in the plan and in this document

DOE Fuel Cell Report to Congress

Another document that provides a framework for the Multi-Year RD&D Plan is *DOE's Fuel Cell Report to Congress* (February 2003). This report summarizes the technical and economic barriers to the use of fuel cells in transportation, portable power, stationary, and distributed power generation applications, and also provides a preliminary assessment of the need for public-private cooperative programs to demonstrate the use of fuel cells in commercial-scale applications by 2015. Specifically, the report recommends federally sponsored programs to do the following:

- Focus on advanced materials, manufacturing techniques and other advancements that will lower costs, increase longevity, and improve reliability of fuel cell systems

- Increase emphasis on hydrogen production and delivery infrastructure, storage, codes and standards development, and education
- Develop public-private learning demonstrations, namely, a transportation and infrastructure partnership, as an integrated means of addressing commercialization barriers through collaboration between energy and auto industries.

U.S. DRIVE Partnership

In January 2002, the FreedomCAR Partnership was established as a research and development collaboration between the Department of Energy and the U.S. Council for Automotive Research (USCAR), a partnership formed by Ford Motor Company, Chrysler Corporation, and General Motors Corporation. In September 2003, the Partnership was expanded to the FreedomCAR and Fuel Partnership by bringing the major energy companies (BP America, Chevron Corporation, ConocoPhillips, ExxonMobil Corporation and Shell Hydrogen) to the group. In June 2008, the Partnership was expanded to include two utilities, DTE Energy and Southern California Edison. In May 2011, the Partnership was expanded once again to include the Electric Power Research Institute and Tesla Motors and was renamed U.S. DRIVE Partnership (U.S. DRIVE) where DRIVE represents Driving Research and Innovation in Vehicle efficiency and Energy sustainability.

U.S. DRIVE facilitates frequent and detailed pre-competitive technical information exchange on a broad portfolio of technologies, including hydrogen and fuel cells. By providing a framework for discussing RD&D needs, developing technology roadmaps, and evaluating RD&D progress, U.S. DRIVE helps accelerate RD&D progress, avoid duplication of efforts, and ensure that DOE RD&D targets support industry commercialization needs. These technologies will reduce the dependence of the nation's personal transportation system on imported oil and minimize harmful vehicle emissions, without sacrificing mobility and vehicle choice.

Energy Policy Act of 2005 and Energy Independence and Security Act of 2007

The Multi-Year RD&D Plan also directly supports the *Energy Policy Act of 2005* and the *Energy Independence and Security Act of 2007*. The Plan serves not only to establish the milestones and tasks of the programs, but also reports goals, challenges, and progress to the Secretary of Energy, Congress, and stakeholders. These historic pieces of legislation support many of the principles outlined in the *National Energy Policy* to strengthen our nation's electricity infrastructure, reduce dependence on foreign oil, increase conservation, and expand the use of clean, renewable energy.

Title VIII of EPACT 2005 focuses on hydrogen and Title I of EISA 2007 focuses on improved vehicle fuel economy including fuel cells and reflects strong Congressional support for research and development of hydrogen and fuel cell technologies. These two Acts make the long-term commitment necessary for a market transformation by authorizing the Hydrogen and Fuel Cell Technologies Program through 2020 and by requiring coordinated plans and documentation of the Program's activities.

1.5 Scope of Multi-Year RD&D Plan

Implementation of the FCT Program will be governed by its Multi-Year RD&D Plan, which covers the period 2004 through 2020 and describes the activities of the FCT Program. The Plan addresses technologies for hydrogen production, delivery, storage and infrastructure, as well as fuel cells for transportation, stationary, and portable power applications. Government resources for these RD&D activities will be fully leveraged through partnerships with industry as the nation moves toward hydrogen as an energy carrier. The Plan's aim is to bring technologies to the point where early adopters can begin implementation and manufacturers can invest in plant and capital equipment with confidence that markets are emerging.

Planned activities are focused on technologies for hydrogen production, delivery, and storage; fuel cells for transportation, portable, and stationary applications; technology validation; codes and standards; safety; education; systems analysis; systems integration; manufacturing and market transformation. Goals, objectives, and technical targets are identified through 2020 for each of the sub-programs, and milestones and schedules are identified through 2020. While the government's role is essential to advancing hydrogen and fuel cell technologies in the early stages of development, once the technical targets are validated in a systems context, the government's role will diminish and industry will complete commercialization. The government will help by promoting market transformation through policy and incentives and support of early adopter activities. Funding for RD&D in each sub-program will be scaled according to measurable progress and determined needs—as technical and cost targets are met or missed, funding for particular technological approaches will be adjusted. When performance, safety, and cost targets are met, a sub-program's RD&D funding will be redirected as appropriate. If specific performance issues remain at that time, RD&D could be extended if the risk of the continued effort is justified by the potential benefit. To continue moving efficiently toward the goal of technology readiness, the Plan will be updated periodically to reflect technological advances, system changes, and policy decisions.

1.6 Program Evaluation

The Department of Energy commissioned the National Academies to review the June 2003 draft RD&D Plan. Almost all of the resulting report's recommendations have been incorporated into the FCT Program. Some of the significant points in the report were as follows:

- Establish a comprehensive systems analysis capability to drive technology development decisions relevant to energy, environmental and economic criteria
- Establish an independent systems integration effort to ensure that the various sub-programs (such as Production, Delivery, and Storage) fit together seamlessly
- Increase emphasis on hydrogen safety to understand how hydrogen systems must be designed, built, and operated differently from today's vehicles and infrastructure
- Engage universities to play a much bigger role in the research program.

The actions taken in response to these recommendations include the enhancement of the FCT Program's systems analysis capabilities, establishment of a Systems Integration Office, creation of a

hydrogen safety experts panel to help DOE audit safety plans and practices within the FCT Program; and the competitive selection of numerous universities to carry out hydrogen and fuel cell technologies research.

In addition, DOE created the Hydrogen and Fuel Cell Technical Advisory Committee (HTAC) in 2006. The Committee's responsibility, as required by EPACT, is to provide technical and programmatic advice to the Energy Secretary on hydrogen research, development, and demonstration efforts. The Program's Annual Merit Review and Peer Evaluation provides an additional means of assessment. At this annual meeting, projects within the Program are reviewed by experts. These reviews may be used to make changes in the scope and direction of the projects.

1.7 Program Coordination

The DOE Hydrogen and Fuel Cells Program coordinates its activities with other Federal agencies, with States and regional entities by participating in organizations such as the California Fuel Cell Partnership, and with other countries through the International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE) and the International Energy Agency and its relevant implementing agreements.

In November 2003, the United States hosted the inaugural Ministerial meeting of IPHE, which brought together 16 countries and the European Union and helped launch international cooperation on vital hydrogen-related research activities. Additional meetings, including ministerial meetings, have enabled the IPHE to provide a mechanism to organize, evaluate, and coordinate multinational research, development, and deployment programs that advance the transition to a global market transformation. The IPHE leverages resources; identifies promising directions for RD&D and commercial use; provides technical assessments for policy decisions; prioritizes, identifies gaps, and develops common recommendations for international codes and standards and safety protocols. Additionally, the IPHE maintains communications with the key stakeholders to foster public-private collaboration that addresses the technological, financial, and institutional barriers to a cost-competitive, standardized, widely accessible, safe, and environmentally benign market transformation.

In accordance with the *Energy Policy Act of 2005*, the Interagency Hydrogen and Fuel Cell Technical Task Force was formed to work toward safe, economical, and environmentally sound hydrogen and fuel cell technologies by coordinating the efforts of the Office of Science and Technology Policy; the Departments of Energy, Transportation, Defense, Commerce, and Agriculture; the Office of Management and Budget; National Science Foundation; Environmental Protection Agency; National Aeronautics and Space Administration; and other agencies as appropriate. The Task Force created a website at www.hydrogen.gov to provide information on all Federal hydrogen and fuel cell activities. An interagency working group under the Task Force meets monthly to coordinate efforts among Federal agencies.