**Final Report**

# Fueling the Future

## Better Ways to Use America's Fuel Options

**A Report of**
**The Consumer Energy Council of America**
**Fuels and Technologies Forum**

**May 2006**

CECA
Consumer Energy Council of America

Founded in 1973, the **Consumer Energy Council of America** (CECA) is the nation's senior public interest energy policy organization. CECA is a leading national resource of information, analysis and technical expertise on the social and economic impacts of energy policies. CECA has a primary commitment to ensuring reliable and affordable essential services for all consumers, with special regard for residential and small business consumers. CECA provides a forum for consensus-building among public and private sector organizations, Members of Congress and their staff, Federal and State regulators, industry leaders, consumer advocates, environmentalists, academics, and other constituencies in furtherance of public policy objectives.



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CECA
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*CECA is especially grateful to the U.S. Department of Energy and its national laboratories for their commitment to supporting the CECA Fuels and Technologies Forum. CECA is grateful as well to the many public and private sector organizations that provided generous financial support.*

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*Associations providing support include Edison Electric Institute, National Corn Growers Association, National Hydropower Association, National Oilheat Research Alliance, National Rural Electric Cooperative Association, and the Nuclear Energy Institute. Private sector entities that provided support include American Electric Power, Areva Enterprises, Chevron Corporation, Constellation Generation Group, DTE Energy, Duke Power Company, KFx Inc., PG&E Corporation, R.W. Beck, and Southern Company.*

# Acknowledgements


May 2006

In July 2005, the Consumer Energy Council of America (CECA), the nation's senior public policy organization focusing on energy issues in the consumer interest, commenced the Fuels and Technologies Forum (CECA Forum) to address ways to optimize the nation's fuels and technologies to meet stationary energy needs. In doing so, the goal of the CECA Forum was to develop consensus-based public policy recommendations to ensure consumers would benefit from decisions made on the use of fuels and fuel technologies over the next 20 years.

The CECA Forum developed a set of National Consumer Priorities and examined fuels and technologies issues through the prism of these consumer priorities. This analysis became the basis upon which the CECA Forum made policy recommendations.

The use of the National Consumer Priorities as the prism through which the analysis was undertaken has culminated in this landmark report that provides valuable guidance to policymakers when addressing the complex issues related to fuel supply, fuel availability, and technology research, development, and deployment.

We are profoundly grateful to the **Honorable J. Bennett Johnston**, Chair of the CECA Forum, President and Chief Executive Officer, Johnston and Associates, and retired Chairman of the U.S. Senate Committee on Energy and Natural Resources, for his statesmanship in guiding the deliberations among the members and for the generous amount of time he gave to the service of the CECA Forum. We are grateful for his astute ability to reach consensus among the members of the CECA Forum who represented a broad range of stakeholder interests and widely diverse perspectives.

CECA is also indebted to the leadership of the Working Group Co-Chairs who led participants through intense debates and guided the CECA Forum through the recommendations process. The Fossil Fuels Working Group was ably led by **Mr. Carl Bauer**, Director, National Energy Technology Laboratory, and **Mr. Robert Hanfling**, President and Chief Operating Officer, KFx Inc. Both Messrs. Bauer and Hanfling skillfully led the Working Group's deliberations on coal, natural gas, petroleum, and carbon management issues, and the overarching issues of infrastructure needs, the role of government, and research and development requirements.

We want to acknowledge several members of the Fossil Fuels Working Group who gave of their time and talent to develop white papers, including **Mr. Robert Kripowicz**, President, Milestone Consulting and former Deputy Assistant Secretary, U.S. DOE, Office of Fossil Energy, who authored a paper on the role of government; **Mr. Robert Bessette**, President, Council of Industrial Boiler Owners, who authored a paper on distributed generation and combined heat and power; **Bharat Patel, Ph.D.**, Director of Planning, New Jersey Board of Public Utilities, who authored a paper on natural gas and liquefied natural gas issues; **Mr. Roger Kranenburg**, Director of Business Development, Edison Electric Institute, who, with assistance from his colleagues, authored papers on carbon management and on mercury; **Mr. Dale Heydlauff**, Vice President, New Generation and Corporate Technology Development, American Electric Power Company, who authored a paper on infrastructure issues; and **Mr. Richard Aiken** and **Mr. Craig Sutton**, CECA technical consultants from Booz Allen Hamilton, who, working collaboratively with **Mr. Bauer** and his staff, authored a paper on the nexus between energy needs and water availability.

The Nuclear Energy Working Group was expertly led by the **Honorable Laura Chappelle**, Commissioner of the Michigan Public Service Commission, and **Ms. Angelina S. Howard**, Vice President, Office of the President, Nuclear Energy Institute. The Co-Chairs undertook deliberations on a series of high-priority issues including disposition of used nuclear fuel, nuclear fuel reprocessing, and the overarching issues of the role of government, the role of nuclear energy in the climate debate, infrastructure and workforce challenges, and technology research and development needs.

CECA wishes to thank the volunteer authors of the white papers that were developed for the Nuclear Energy Working Group, including **David J. Hill, Ph.D.**, Deputy Director for Science and Technology, Idaho National Laboratory, who served as lead author of a paper on management of used nuclear fuel. We also thank **Ernest Moniz, Ph.D.**, Cecil and Ida Green Professor of Physics, Massachusetts Institute of Technology; **Richard Meserve, Ph.D.**, President, Carnegie

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The Renewables, Energy Efficiency, and Climate Change Working Group benefited from the outstanding leadership of the **Honorable Michael R. Peevey**, President of the California Public Utilities Commission, and **Mr. Robert W. Fri**, Visiting Scholar at Resources for the Future and former President of Resources of the Future. This Working Group had a broad charter and focused on the role of renewable energy and energy efficiency in the nation's fuels portfolio; reliable integration of renewable resources into the electric grid; the role of energy efficiency in a diversified fuels portfolio; research and development requirements, and the overarching issues of climate change, carbon management, and the role of government.

Several Working Group members served as lead authors for the issue papers, including **Mr. Jay Morrison**, Senior Regulatory Counsel, National Rural Electric Cooperative Association, who authored a paper on the role of government in supporting renewables and energy efficiency; **Ms. Kathy Treleven**, Manager, State Agency Relations, Pacific Gas & Electric, who authored a paper on policies needed to integrate renewable energy resources into the grid in a reliable way; **Mr. William Prindle**, Deputy Executive Director, American Council for an Energy Efficient Economy, who authored a paper on policy options for increasing energy efficiency's contribution to our future energy needs; **Ms. Judi Greenwald**, Director of Innovative Solutions, and **Ms. Kathryn Zyla**, Research Fellow, the Pew Center on Global Climate Change, who authored a paper on climate change issues; and **Mr. Andrew Spahn**, Senior Associate, Association of State Energy Research and Technology Transfer Institutions, who authored a paper on clean energy R&D priorities.

We sincerely thank the outstanding team at Booz Allen Hamilton, expertly led by **Mr. Richard Aiken**, Senior Associate, supported by **Mr. Craig Sutton**, Associate, and **Mr. Joel Fetter**, Consultant, who served as technical consultants to the CECA Forum and who undertook original research and analysis which served as the basis of the CECA Forum's deliberations. The Booz Allen team dedicated many long hours to the successful completion of this project and we are extremely grateful for their contributions.

We also want to acknowledge CECA's excellent staff, including **Mr. Davis Bookhart**, independent consultant and former CECA Senior Project Director, who assisted with research, editing, and providing other valuable input. We could not have completed the CECA Forum without the total dedication of **Ms. Kim Kowalski**, CECA's Director of Finance and Administration, who kept the organization focused so that deadlines were met, work products were delivered, and meetings were successfully conducted. Finally, we want to thank CECA's four public policy interns who provided research assistance: **Ms. Peggy Foran**, Boston University, **Ms. Lakshmi Alagappan**, Stanford University **Mr. Ely Jacobsohn**, University of Delaware, and **Ms. Louisa Domingo**, Hendrix College.

Sincerely,

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***DISCLAIMER***

*CECA appreciates and is grateful for the valuable assistance and thoughtful critiques provided by members of the CECA Fuels and Technologies Forum. An attempt was made to reach consensus on as many issues as possible in this report. Nevertheless, the Members of the CECA Forum do not necessarily approve, disapprove, or endorse the report. CECA assumes full responsibility for the report and its contents.*

# Letter From The Chair And Working Group Co-chairs

May 2006

As the Chair and Working Group Co-Chairs of the CECA Fuels and Technologies Forum, we are proud to provide this landmark report, *Fueling the Future: Better Ways to Use America's Fuel Options*, to Federal and State policymakers, energy leaders, energy consumers, the public and the media. This report recommends policies to ensure that the Nation's stationary energy needs can be met through the 20 year period (2005-2025) of the CECA study. The CECA Forum has placed special emphasis on the need to benefit consumers through a diversified fuels portfolio.

We also placed a premium on climate-friendly technologies to allow the continued use of the Nation's abundant supplies of coal and to optimize the benefits of other fossil fuels. We recommend ways to manage used nuclear fuel so nuclear energy, which produces no greenhouse gases, can continue to play a significant role in the fuels portfolio. We recognized at the outset that no single fuel can meet the Nation's energy needs, that each fuel has its opportunities and challenges, and that policies are needed to optimize the use of each fuel to meet consumers' increasing demands.

As the U.S. economy grows over the next two decades, there will continue to be critical issues that energy policymakers must confront. Consumer needs can only be met if the Nation's energy systems continue to provide reliable, environmentally responsible, affordable, and secure power. Government must play an important role in determining how those requirements can be met, what policies are needed, what funds must be appropriated for research and development, and what incentives will promote the deployment of new energy technologies.

The key areas of focus in this report – the critical need for fuel diversity, deployment of breakthrough technologies, a fuel supply that meets the clean air and water needs of the Nation's citizens, the vital role that government must play to support new energy technologies, and the pressing need to upgrade the Nation's energy infrastructure – should be the basis for all energy policy decisions.

We believe that *Fueling the Future* is unique in that we evaluated all fuels and examined how each fuel and its related technologies impact consumer costs and benefits. We analyzed each fuel through the prism of a set of National Consumer Priorities that served as the basis for the CECA Forum's policy recommendations. Importantly, the report presents a balanced assessment of the pros and cons of policy options so policymakers will have the tools to guide their own decisions to fit their special circumstances.

We believe that to meet the Nation's growing need for increased fuel supply in the near term, which this study defined as through 2025, the fuel supply system must be responsive, adaptive, and affordable. Therefore, where the benefits of implementing new technologies or public policies outweigh the costs, we believe that it is in the consumers' best interest to adopt such improvements. This report outlines the various options for optimizing the Nation's fuels portfolio, deploying new technologies, and determining the appropriate role of government in a world in which carbon management issues are increasingly important.

We urge you to read this report. You will likely agree with some parts of the report and disagree with others. The participants of the CECA Forum also had disparate views on the details. However, all of us agree that the findings and recommendations provided herein will provide greater knowledge and understanding of fuels and technologies. This will assist policymakers to evaluate options of how to move forward to meet consumers' demand for clean, affordable and reliable energy. We encourage you as policymakers, industry leaders, and concerned citizens to use these findings and policy recommendations as a benchmark for developing and supporting energy policy for the benefit of all consumers.

Sincerely,

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# Executive Summary

## Introduction

Today's energy systems are rapidly shifting and constantly responding to new challenges. The energy industry is under increasing pressure to address critical social, economic, and environmental challenges. How these social, economic, and environmental challenges are dealt with over the next two decades will have profound impacts on consumers.

It is clear that the growing and cumulative impacts of energy policy decisions will require policymakers to determine national and global priorities for the nation's energy resources. Consumers' increasing demands for cleaner air and water will challenge industry to meet these needs while competing in a global economy. Electric power quality and reliability are more important today to consumers because digital microprocessors are ubiquitously embedded in industrial systems and high quality power is required for their use. Since the terrorist attacks of September 11, 2001, concern has increased over the possibility of future attacks on energy facilities and resultant supply disruptions. All of these developments force a fresh examination of energy systems from a consumer standpoint so that cost, reliability, environmental stewardship, and security are enhanced over the next 20 years.

## Need for the CECA Fuels And Technologies Forum

The demands of the 21st Century require the energy industry to become more adaptive and transformative—an increasingly difficult task for an industry in which facilities take years to build and fuels infrastructure takes decades to develop. In evaluating the supply and demand for fuels and associated technologies, the Consumer Energy Council of America (CECA) identified an overarching issue for examination: *What policies are needed today to ensure the best mix of fuels to meet the nation's social, environmental, and economic needs 20 years from now?*

Many actions have taken place in recent years that will help shape the nation's fuels and technologies mix. Congress recently passed the Energy Policy Act of 2005 (the Act) which outlined several near- and long-term fuels policies; many States have instituted new resource adequacy programs to determine future fuel use, including the implementation of Renewable Portfolio Standards (RPS); regional planning entities, such as Regional Transmission Organizations and Independent System Operators (RTOs/ISOs), have the responsibility of regional planning which takes into account fuel supply and availability, generation planning and transmission planning; the nation's industries are calling for lower prices and better options based on concern over volatile fuel prices; and consumers continue to demand cost-effective measures, fuel choices, and advanced technologies to provide the benefits of new products and services.

To determine how to best meet future energy requirements and to develop guidance for policymakers on these critical issues, CECA launched the Fuels and Technologies Forum (CECA Forum). The CECA Forum, comprised of experts representing major stakeholder interests from the public, private, and non-profit sectors, came together to address the urgent need for insightful, objective, and innovative policy approaches to maximize benefits, minimize costs, and ensure the most beneficial mix of fuels to meet the nation's energy needs through 2025, the timeframe of the CECA Forum's analysis. Set against a backdrop of escalating energy prices and a continuing debate in Congress and in the States on the future direction of energy policy, the CECA Fuels and Technologies Forum is the first integrated approach to exploring national fuel use and the impact of policy choices from the consumer perspective.

## Scope and Analysis

The CECA Fuels and Technologies Forum focused its examination on energy needs in the stationary sector, considering its multi-fuel infrastructure and its direct impact on all consumers. CECA recognizes that fuel and technology options for the transportation sector are equally important to the security and environmental and economic sustainability of the nation. However, those issues are beyond the scope of this study. In its analysis and deliberations, the CECA Forum considered the following three primary sources of energy consumption in the stationary sector:

*Power Generation* – The conversion of fuels to generate electricity constitutes the single largest segment of energy consumption in the stationary sector. This includes generation by public and private utilities, including investor owned utilities; Federal power authorities, such as the Tennessee Valley Authority, that control generation as well as transmission and distribution (T&D) assets; public power systems and rural electric cooperatives that are dependent on others to provide transmission services, known as "transmission dependent utilities" (TDUs); independent power producers (IPPs) that sell electricity into wholesale electricity markets; and, to a more limited extent, specialized energy services such as combined heat and power (CHP).

*Heating and Cooling* – Many industrial processes burn fossil fuels to generate heating and cooling in manufacturing processes. Residential and commercial buildings require direct use of fuels to provide space heating and cooling. The Northeastern States, in particular, and other regions of the country rely on petroleum-based products to provide heat during the winter.

*Industrial Feedstock* – Industrial processes utilize carbon-based fuels as feedstock for the production of other end-use products. As such, fuels used as feedstock are not consumed for their heat content, as is the case in the production of power. Industries such as petrochemicals rely heavily on feedstock, the price of which can affect the economic viability of the industry. CECA's study considers use of feedstock, because it constitutes a noteworthy dynamic for stationary sector consumption applications.

## Evaluation Criteria

Recognizing that consumers will be best served through the availability of a diversified portfolio of fuels, the CECA Forum based its evaluation of fuels on the premise that traditional fuels will continue to be used in the nation's portfolio through the 2025 timeframe of the CECA Forum's study. The CECA Forum developed the following National Consumer Priorities as the prism through which its analysis was conducted:

- *Environmental Protection* – Air and water quality, including the impact on global warming, must not be compromised by fuel use in order to ensure the health and well being of all Americans and their environment.
- *Affordable and Predictable Energy Services* – Consumers, especially low- or fixed- income consumers, must be assured that power is available that is both predictably and affordably priced.
- *Sustainable Economic Development* – The national economic engine must run smoothly and continue to grow and compete in the global marketplace while making the best use of available resources.
- *Reliable and High Quality Energy Services* – High quality and reliable power is a necessity for many industries, including those industries that rely on fuel as feedstock.
- *Public Safety* – Citizens must be protected from any potential harm caused by energy systems.
- *System Security* – Energy systems must be sufficiently reliable to withstand disruptions caused by acts of nature or accidental or deliberate human actions. In addition, the importation of fuel resources from international suppliers must not result in harmful geopolitical impacts. Finally, energy systems must be effectively interdependent so that when one system is affected, the entire fuels infrastructure is not harmed, costing consumers in lost products and services.

## How Fuels Measure Against the National Consumer Priorities

Over 70 percent of electricity consumed in the U.S. is generated through the combustion of hydrocarbons—primarily coal, natural gas, and oil—creating nitrogen oxide, sulfur dioxide, and carbon dioxide emissions. The nation's reliance on fossil fuels demonstrates that tradeoffs must be made between convenience, price, and the environment in order to sustain economic expansion.

For instance, coal produces environmental costs but it also provides important benefits. It is affordable and abundantly available. *Renewable energy resources*, such as hydropower, wind power, solar power, geothermal, ocean thermal, and biomass gasification, are characterized by other kinds of costs and benefits. Renewable energy resources show great promise as low emissions technologies, but siting, footprint, and aesthetics issues, as well as high development costs and limited production capacity, serve as barriers to wider implementation of most renewable energy resources.

A careful examination of *diesel technologies* demonstrates the tradeoff between costs and benefits. Diesel generators, excellent choices for peak demand and stand-by capacity in the electric power industry, produce 30 percent less greenhouse gas emissions (GHGs) than gasoline-powered reciprocating engines for the same amount of power. However, from an air quality standpoint, diesel engines produce much higher levels of other airborne pollutants, such as particulate matter, sulfur and nitrogen oxides. Clearly, the end goal—whether it is reduction of greenhouse gases or reduction of unhealthy airborne emissions—should be a significant factor in determining how fuels are used in the future and how technologies can improve the characteristics of each fuel.

In the case of *nuclear energy*, nuclear power plants are capable of generating large and reliable amounts of zero-emissions electricity, but used nuclear fuel resulting from the nuclear energy process must be stored safely and securely. Progress has been slow in implementing the Congressionally-mandated long-term method of storage of used nuclear materials, namely, a repository at Yucca Mountain, Nevada. Thus, no long-term used nuclear fuel storage repository has been licensed to date in the U.S. Issues such as nuclear waste storage, proliferation of nuclear materials, safety, and siting of new nuclear power plants are challenges to the greater use of nuclear energy.

In the *home heating* industry there are tradeoffs between convenience and cost. *Natural gas*, for example, can be used in condensing boilers that increase the efficiency of the boilers to extremely high levels. However, consumers need to balance the long-term economic benefits of using high efficiency equipment with the fact that the natural gas industry is experiencing supply constraints and record high prices, meaning that consumer prices can spike with little notice. *Heating oil and propane* have similar tradeoffs. In terms of environmental and cost tradeoffs, the production of biodiesel provides consumers with a choice of a renewable, environmentally friendly fuel for home heating, although it may be somewhat more expensive than traditional heating oil. The availability of very high efficiency heating oil equipment makes heating oil an important option for residential consumers.

There are many consumer benefits in utilizing a diverse fuels portfolio. Maintaining alternatives as a hedge against rising prices, protection against natural or man-made supply disruptions, and ensuring a healthy environment are only a few of these benefits. However, there is no magic bullet for meeting the nation's stationary energy needs and each fuel comes with its own suite of costs and other externalities. To meet growing demand, the nation must make optimal use of all of its fuel resources. Weighing and properly addressing these costs and benefits will ensure the optimal use of fuels in the diversified fuels portfolio as the nation moves to meet its growing energy demand.

## The CECA Process

With over 30 years expertise in conducting research and formulating energy policies on the most important energy issues confronting consumers, CECA consistently finds that the most enduring recommendations are forged through consensus-based processes. CECA undertook this initiative recognizing that sound public policy is best developed when stakeholders have an ability to voice their interests, concerns and ideas, debate issues, and come to agreement on a best course of action to guide public policy.

CECA's consensus-building process emphasizes the candid, constructive expression of views and information by stakeholders as a means of minimizing partisan and ideological differences. The CECA Forum's consensus-building process remains an essential differentiator between its recommendations and those of trade groups, interest-driven, or other non-profit organizations. Debate and evaluation of competing ideas within a set of criteria defined and agreed to by the participants is undertaken with the goal of coming to consensus. This marketplace of ideas and information provided by the CECA Forum allows participants to test various approaches, refine ideas, evaluate problems, and develop viable solutions. As a result, CECA's recommendations incorporate the most up-to-date information and have undergone a rigorous vetting process by national thought leaders representing a broad range of stakeholder interests with an equally diverse range of views. This helps to reduce significantly many of the political and legal battles that accompany implementation of new policies and legislation.

The recommendations contained in this report are methodically built using detailed research from leading national and international institutions, a focused consensus-building process among leading stakeholders, and extensive outreach and education on the findings and recommendations of the CECA Forum. Nevertheless, CECA takes full responsibility for the final report and for its findings and recommendations.

## Findings And Recommendations On Specific Fuels And Technologies

A broad portfolio of fuels and technologies will be required to meet the nation's projected energy demands through 2025. New technology breakthroughs, potential climate change policy shifts, and changing economic priorities will affect the nature of the energy portfolio over the next 20 years. It is clear, however, that the major fuels used today to meet stationary energy needs will remain the largest contributors to the fuels portfolio in 2025. Therefore, it is important that policies and programs be adopted to maximize the positive attributes of each fuel and minimize the negative characteristics of each fuel.

## Coal

Coal is the nation's most abundant fuel source and the U.S. will continue to depend on coal to play a critical role in meeting future domestic energy demand growth. It represents one of the most affordable energy sources for consumers and coal prices have been relatively stable. With proven reserves estimated at 250 years at current consumption levels, coal represents a dependable and abundantly available domestic resource. Coal has proven to be a reliable source of high quality energy, fueling over half of the nation's current electricity generation capability.

However, coal also has substantial environmental challenges, which may accumulate as the domestic and global coal resource base and infrastructure grows. In addition to NOx and $SO_2$, two of the Clean Air Act's criteria pollutants, coal, with the highest carbon to energy ratio among fossil fuels, faces another environmental challenge – mercury, a focus of new clean air regulations. Much of the technology development in recent years has been designed to address these environmental challenges. As a result, a new generation of coal-fired power generation systems is ready for demonstration and deployment, while the use of coal as a substitute for high priced natural gas in the industrial sector is now being explored. Additional research into more efficient environmental control technologies, including carbon capture, and in understanding the geologic and chemical implications of carbon sequestration is also underway.

Because of its carbon/energy ratio, developing clean coal technologies, including carbon capture and storage, is key to expanded use of coal in the nation's future energy portfolio. To best meet consumer and environmental requirements, the market for coal infrastructure growth will need to be dominated by the most environmentally friendly advanced coal technologies available. In that regard, it is important that the entire life cycle of coal processes – from coal mining and pre-combustion processes, such as beneficiation, through stack emissions – be considered.

### CECA Forum Findings on Coal

The CECA Forum found that the positive attributes of coal indicate that it will be an important part of the fuels portfolio through the 2025 timeframe of the CECA study. In addition, one of the most challenging of the National Consumer Priorities for coal – that of environmental responsibility – can be satisfactorily addressed through advances in new technologies. Further, the CECA Forum found that:

- In recent years funding for coal sequestration research and development (R&D) has been stagnant and there has been inadequate funding for demonstration of clean coal technologies.
- The breadth of technologies available will allow users the flexibility to reduce environmental impacts at the pre-combustion stage (i.e., coal beneficiation), post-combustion (emissions-capture technologies), or a combination (integrated gasification combined cycle (IGCC)).
- Clean coal technologies may have significant co-benefits, such as the production of electricity, hydrogen, and industrial grade chemicals and minerals and may represent a viable alternative to high priced natural gas for much of the nation's industrial applications.
- Technologies that reduce or mitigate greenhouse gas emissions, such as IGCC and sequestration, are critical to meeting the nation's shared climate goals.
- The Federal government should take a leadership role in addressing the global problem of airborne mercury and engaging the international community in developing a global strategy for the reduction of international transport of airborne mercury. The U.S should take the leadership in developing a global cap-and-trade or other market-based mechanisms for reducing the emissions of mercury.
- In addition to research designed to address climate-related issues associated with coal use, increased research and development is necessary to improve environmental and overall performance of the existing power generation fleet in the U.S., as well as into alternative uses of coal to help alleviate impacts from high oil and natural gas prices and constrained supply.

### CECA Forum Recommendations on Coal

CECA's coal recommendations are based on the CECA Forum's consensus that research and development into new technologies to reduce emissions will significantly improve coal's environmental performance and allow it to continue to play a major role in the nation's diversified fuels portfolio through the 2025 timeframe of the CECA study.

1. *CECA recommends that commercial processes and advanced clean coal technologies comprising the entire coal fuel cycle be promoted with increased funding for demonstrations and incentives to facilitate widespread deployment, leading to increased efficiency and reduced environmental consequences. Further, CECA recommends:*

- *Expedited implementation of the loan guarantee programs authorized by the Energy Policy Act of 2005 and strongly urges Congress to appropriate funds to allow non-fee-paid projects to take advantage of these programs.*

- *Expansion of the investment tax credit for clean coal technologies beyond the initial limitation to allow for more widespread deployment and more diversity in application and technology.*

- *Full funding of increases in the clean coal research program as authorized in the Energy Policy Act of 2005 and expansion of this program to incorporate research leading to increased use of coal-based fuels for transportation and industrial use.*

2. *CECA further recommends the advancement of clean coal technologies, including Integrated Gasification Combined Cycle (IGCC), and recommends full or increased support for the programs and funding levels in the Energy Policy Act of 2005, specifically:*

   - *Increased funding for carbon sequestration programs to allow continuation of Regional Partnerships, extensive research and development efforts on carbon capture and sequestration techniques, and large-scale demonstration of promising technologies.*

   - *Increased funding for the integrating technologies necessary to produce capture-ready streams of carbon dioxide in coal-fired generating plants, as well as gasification and hydrogen separation technology.*

   - *Increased funding for research on innovative commercial demonstrations of clean coal technologies, combustion systems, fuel cells, research into the applicability of different coals for IGCC technologies, coal to liquids technologies that produce diesel fuel and gasoline, and power plant water management technologies.*

3. *CECA supports the development of FutureGen, a near-zero emissions coal plant, and recommends that this facility be closely integrated into the research, development, and demonstration of innovative technologies taking place in other fossil energy programs to assure their demonstration in the FutureGen facility.*

4. *CECA recommends that in developing a mercury regulation the Federal government look at all sources, not just stationary ones. CECA further recommends that:*

   - *Policy be created accounting for all technology and process solutions which remove mercury and reduce mercury emissions, from pre-combustion to post-combustion.*

   - *The Federal government take a leadership role in convening an International Conference on the international transport of airborne mercury to highlight the magnitude of the problem and to develop a strategy for international cooperation on mitigation and standards, including a cap-and-trade program which would complement that developed in the U.S.*

## Natural Gas

Natural gas is a major source of energy for all stationary energy needs. Its positive environmental attributes have played a major role in the increasing reliance on gas by the power generation sector. It remains a major feedstock and a source of process steam and heat for the industrial sector and is a significant fuel for heating and cooling for the residential and commercial sectors.

However, the volatility and escalating prices of natural gas have had significant impacts on consumers' heating costs and electric bills. Likewise, recent increases in the price of natural gas have had devastating impacts on the chemical and other industries that use natural gas as a feedstock, have contributed to significant employment losses in those sectors, and have resulted in the relocation of U.S. industrial facilities abroad.

The continued growth of natural gas-fired electricity capacity to address the projected growth in electricity demand may be limited due to issues of availability and price. Natural gas has been one of the most volatile of the energy fuels in recent years. With the recent high prices of natural gas, investors face a higher level of risk in new projects. From a consumer perspective, this translates into higher prices and delays or deferrals of much needed electric generation capacity, with the potential for use of less efficient and more costly capacity.

A significant reason for these price concerns is due to projected supply constraints in the North American market. Unlike oil, natural gas is not easily traded on the global markets. Thus, the supply questions in the North American market dominate the issues relating to natural gas. In 2003, the National Petroleum Council (NPC) projected a 25 percent shortfall in supply of natural gas from conventional sources compared to projected demand in 2025. Similarly, the U.S. Department of Energy's Energy Information Administration (EIA) projected an 8.7 trillion cubic-foot (tcf) gap in domestic natural gas production by 2025. As recently evidenced, the market has tightened much sooner than expected, exacerbated by a decline in imports from Canada, which are forecast to decrease to 2.6 tcf by 2025 due to both the depletion of resources as well as Canada's own increasing demand.

Liquefied natural gas (LNG) is emerging as the most significant and controversial issue in natural gas supply. Importation of LNG would give the U.S. access to natural gas resources throughout the world. Imported LNG is the source of natural gas that has the potential to be developed most rapidly to meet the shortfall. Some argue that without access to the larger supply of worldwide natural gas made possible by the importation of LNG, the U.S. will face higher natural gas prices and be more susceptible to unexpected supply shortfalls. Others contend, however, that world demand for LNG from China and other fast growing economies could move the price of LNG higher on the global market and U.S. domestic gas prices would rise to match those levels. Even if imported LNG were to lower prices temporarily, some suggest additional demand would drive prices back up. Further concerns about safety and siting of LNG facilities could seriously impact the role LNG plays in the U.S.

## CECA Forum Findings on Natural Gas

There is no question that natural gas plays an essential role in the portfolio of fuels needed to meet stationary energy needs. Because of its characteristics and versatility, it is the one fuel that is in high demand across the spectrum of stationary energy applications, including domestic heating, chemical and manufacturing processes, and electricity generation. The CECA Forum found that:

- Because of the importance of maintaining a domestic supply of natural gas, transportation capacity is needed to bring the Prudhoe Bay reserves in Alaska to load centers in the continental U.S. Beyond Alaska, it will be increasingly important to look to ultra deep gas resources and other non-conventional sources of natural gas such as coal-based syngas and coal bed methane.
- Until advanced emissions reduction technologies are available for coal, gas remains the preferred fossil fuel for electricity generation from an environmental standpoint, although price and supply constraints of natural gas are offsetting factors. Once clean coal, carbon capture and sequestration, and other emissions-limiting technologies become more widely available, the environmental advantage of natural gas will diminish.
- There is a need to ensure that LNG, when re-gasified, is compatible with the existing natural gas infrastructure and end-use equipment.
- The disproportionate concentration of natural gas facilities in the Gulf of Mexico creates a supply risk during times of severe disruption, as demonstrated by Hurricanes Katrina and Rita in 2005.
- Research is needed for affordable natural gas substitutes to ensure the sustainability of the nation's critical industrial sector.

## CECA Forum Recommendations on Natural Gas

CECA's natural gas recommendations focus on increasing supply and ensuring that the additional supply will be compatible with the existing natural gas infrastructure. The recommendations support the CECA Forum's goals of promoting safe, affordable, environmentally responsible, and predictable natural gas supplies as part of the nation's diversified fuels portfolio over the next 20 years.

5. *CECA recommends that Federal and State regulators use their siting authority to ensure that if LNG is imported, the location of facilities should be diversified to the extent possible. Given public concern over the safety and siting of LNG facilities, CECA also recommends that such facilities not be placed in close proximity to major population centers and that development of offshore LNG facilities be encouraged.*
6. *CECA recommends that the U.S. Department of Energy develop standards on the impacts of LNG on combined cycle generation facilities to ensure that the existing natural gas power infrastructure is compatible with the use of LNG and that liquid BTU content standards be developed.*
7. *CECA supports increased research and development of technologies and approaches to develop non-conventional sources of natural gas, including methane hydrates, ultra-deep water development, deep gas formations, coal bed methane, shale gas, and syngas from coal or biomass, and encourages the expeditious implementation of such requirements contained in the Energy Policy Act of 2005. Funding for methane hydrates should focus on determining whether the economic and environmentally responsible development of such resources can play a major role in fulfilling the nation's energy needs over the next 20 years.*

## Petroleum and Oil for Home Heating

Residential heating constitutes the largest non-transportation use of distillate fuels, with nearly 10 percent of households in the United States heating their homes with oil. Oil usage for heating is primarily focused on the residential sector (only four percent of commercial facilities heat with oil) and nearly 80 percent of the 8.1 million households that heat with oil reside in the Northeastern region of the country. It is the most tangible fuel for consumers, as heating oil dealers have a direct relationship with their customers, deliver fuel to the home, provide maintenance advice, and service the equipment.

Oil has a small market in new home construction, and the industry is attempting to expand the conversion of electric-heated homes to oil and some conversion of natural gas to oil is also taking place. In 2001, about 6.6 billion gallons of heating oil were sold across the country, with 82 percent sold to consumers in the Northeast. This represents approximately two percent of annual consumption of crude oil in the United States.

From a policy perspective, although environmental restrictions have not been placed on heating oil per se, the U.S. Environmental Protection Agency has placed strict controls on the sulfur content of distillates used for transportation (on-road) purposes and the heating oil industry has voluntarily adopted the goal of providing low sulfur heating oil (0.05 percent sulfur content). This is a significant reduction and equivalent to on-road requirements for at least 80 percent of heating oil customers. This self-imposed environmental goal demonstrates the heating oil industry's initiative in taking the necessary steps to adapt to new environmental conditions while remaining self-regulated.

### CECA Forum Findings on Petroleum and Oil for Home Heating

The CECA Forum found that heating oil currently plays a positive role in domestic heating. It provides consumers an alternative and often cost-effective option to the slate of heating fuels that includes natural gas and electricity. It is the most tangible fuel for consumers and consumers benefit from a direct relationship with their heating oil dealer who delivers fuel oil, services the equipment, and often provides efficiency advice. The CECA Forum found that the option to blend heating oil and biodiesel will provide consumers with another positive and environmentally-friendly choice. More specifically, the CECA Forum found that:

- Price volatility of heating oil during the winter months may be mitigated through increased use of biodiesel.
- The increased use of low sulfur heating oil, along with the growing distribution network for biofuels, will have a positive impact on the environment.
- A wide variety of relatively low cost efficiency measures, such as ceiling and wall insulation, weather stripping around windows and doors, automatic thermostats, and high efficiency equipment can save significant amounts of energy with consequent reductions in consumers' heating bills.
- The development of testing and standards procedures to improve the Annual Fuel Utilization Efficiency (AFUE) rating system could provide more accurate information on the efficiency of home heating systems, leading to better use of equipment, better purchase decisions by consumers, and greater reductions in energy use.

### CECA Forum Recommendation on Petroleum and Oil for Home Heating

CECA's recommendation is based on the importance of heating oil to meet residential consumer needs. Enhancing heating oil with biofuels will result in reduced fossil fuel use, reduced air pollution, and less reliance on imported oil. Furthermore, greater efficiency in the home will reduce the amount of all fuels consumed for heating and cooling and reduce the bills consumers would otherwise pay.

8. *CECA recommends that the Federal government increase funding for biofuels research for heating oil and other applications while also providing increased funds for consumer education on cost-effective energy efficiency measures such as upgrading inefficient burner tips, installing insulation and efficient windows, sealing air leaks in framing and ducts, automatic setback thermostats, and other effective energy-reducing measures. Additionally, CECA recommends that the industry, through the National Oilheat Research Alliance, work with Brookhaven National Laboratory and other Federal laboratories and State agencies, such as the New York State Energy Research and Development Authority, to develop an improved method of evaluating the efficiency of home energy systems and of home heating appliances.*

### Distributed Generation and Combined Heat and Power

Distributed generation (DG) refers to small, modular electricity generators sited close to or at the point of customer load. Some DG technologies take advantage of being close to the customer load by capturing and utilizing the heat released from electricity generation that would otherwise be wasted. Known as co-generation or combined heat and power (CHP), this is the largest potential method of generating electricity from distributed resources. Independent of whether the primary purpose is to generate heat or to generate electricity, when these two services are combined, it is labeled CHP, and is known for a particularly high level of efficiency. CHP can utilize high efficiency gas turbines or more exotic technologies such as large fuel cells, which generate enough heat to be captured and utilized. Other technologies, such as small wind, photovoltaic, or back-up generators, fall into the DG category since the energy is generated close to where it is used.

The average efficiency of power generation in the U.S. has remained at approximately 33 percent since 1960, meaning that 67 percent of the fuel consumed in electricity generation is typically wasted in the form of heat loss. In the U.S., the thermal losses in power plants totaled almost 23 quadrillion BTU's of energy in 1997, representing over 24 percent of total U.S. energy consumption. Approximately seven to eight percent of the nation's current national electricity supply comes from CHP. Theoretical efficiencies of a CHP system can approach 85 percent; more typical efficiencies range from 55 to 70 percent, compared to efficiencies of 28 to 35 percent for traditional utility boiler systems, and 37 to 41 percent efficiency for newer centralized technologies such as super-critical units.

In the appropriate situations, there is substantial value from the distributed energy model that can complement and supplement the centralized model. For example, under the right conditions, DG can enable utilities to defer or eliminate costly investments in transmission and distribution (T&D) system upgrades, concentrate on peaking units rather than baseload capacity, and extend the energy from fuel supplies. DG can incorporate environmentally-responsible sources of energy, such as wind power, solar power, and biomass. DG can provide customers with higher quality power, increased reliability, and lower costs of electricity to consumers. On the other hand, when fuels such as diesel are used in distributed generation, it can be difficult to regulate pollution output from many small point sources. On balance there are strong opportunities for DG to complement energy from central power facilities.

## CECA Forum Findings on Distributed Generation and Combined Heat and Power

The CECA Forum found that there are significant opportunities for DG and CHP to contribute positively to the meeting the nation's stationary energy needs. The CECA Forum also addressed the economic, regulatory, and environmental barriers that must be overcome. More specifically, the CECA Forum found that:

- DG and CHP are most effective in situations that call for a custom solution. In these site-specific situations, the appropriate DG resource may offer superior value compared to other energy resources.
- DG resources, when used in a CHP application, are more effective at utilizing fuel resources because of their higher efficiency ranges and because they eliminate line losses that occur as power is transported over long distances.
- A popular misconception is that all DG resources are environmentally superior to central power resources. While DG includes small renewable resources, such as solar photovoltaics (PV), it also includes mobile diesel generators that may produce more pollutants per unit of energy than central power plants. Unlike central station plants, however, the number of hours that diesel generators can operate in a day is limited by pollution control regulations.
- DG should be considered as a portfolio of available technologies that meets a variety of needs in the stationary energy infrastructure.
- Concerns regarding pricing for DG/CHP stem from rate designs that do not provide the appropriate price signals to prospective DG/CHP host facilities, which may obscure the true cost of electricity.

## CECA Forum Recommendations on Distributed Generation and Combined Heat and Power

CECA's recommendations are based on the high efficiencies associated with DG/CHP and its value in meeting stationary energy needs as part of a diversified fuels portfolio. The recommendations are designed to overcome economic and regulatory barriers to greater market penetration of DG/CHP.

9. *CECA supports the move towards a regulatory environment that is conducive to the implementation of clean and efficient DG/CHP systems and addresses barriers to the deployment of CHP systems in the marketplace. Therefore:*

   - *CECA recommends that the Federal Energy Regulatory Commission (FERC) adopt revisions to the IEEE SCC21 P1547 interconnection standard as they are developed with respect to distributed generation resources for those generators that come under FERC's jurisdiction.*
   - *CECA recommends that State Public Utility Commissions develop fair and equitable rate designs, standby tariffs, back-up requirements, and net-metering or other rules designed to promote widespread implementation of cost-effective, clean and efficient DG/CHP projects.*

## *Nuclear Energy*

Nuclear energy is a key component of the fuels portfolio to meet stationary energy needs, providing 21 percent of the electricity generated within the United States. Nuclear energy has important attributes. It does not produce greenhouse gas emissions and it is an affordable and reliable source of power. For these reasons, there is renewed interest in nuclear energy's role as a climate-friendly source of power. Congressional support for new nuclear facilities is gaining as evidenced by the incentives provided in the Energy Policy Act of 2005. These incentives are designed, at least in part, to address the capital cost and some of the regulatory uncertainties of nuclear energy – especially for the "first movers."

Demand for electricity from nuclear technologies is projected to grow significantly over the next 20 years and beyond. However, no new nuclear power plant has been ordered in the U.S. since 1978 and uncertainties surround the revival of a U.S. nuclear energy industry. The most significant uncertainties involve cost and the regulatory process, used nuclear fuel management, and concerns about safety and proliferation.

There are significant developments that can point the way for an expanded role for nuclear energy in the U.S. The commercial nuclear energy industry, with cost-shared support from DOE, has developed advanced light water reactors and is applying for Nuclear Regulatory Commission (NRC) certification. The NRC revised its certification process in the early 1990s and required that safety issues within the scope of the certified designs undergo an extensive public review process prior to certification. Further, the NRC's new plant regulatory process allows utilities to obtain a single license from the NRC before construction begins to both construct and operate the new plant.

Because all new nuclear power plant designs involve new technology, estimates regarding the cost of new nuclear power plants are uncertain. That uncertainty, coupled with the extra costs associated with a first-of-a-kind facility, led Congress to approve several incentives for the nuclear energy industry in the Energy Policy Act of 2005. Electricity produced from a limited number of qualifying advanced nuclear power facilities can receive a limited production tax credit (PTC) of 1.8 cents per kilowatt hour for the first eight years of operation. Six thousand megawatts (MW) allocated to newly constructed plants will be eligible for this credit.

The discharge from reactors after the production of electricity using nuclear energy is termed "used" or "spent" nuclear fuel. Although the volume of used nuclear fuel is small relative to wastes from other energy production processes, used nuclear fuel is highly hazardous, requiring special equipment and shielding, and careful management.

Utilities generating nuclear energy pay a fee of one-tenth of one cent for each kilowatt-hour of electricity sold by nuclear facilities in order to finance the permanent disposition of nuclear waste. These costs are passed along to consumers in their utility bills. The fees are placed in the general Treasury under the Nuclear Waste Fund (the Fund) and then appropriated to DOE to support the planning, construction, and operation of the nuclear waste repository and the related spent fuel transportation system. However, as a result of changes in Federal budgetary practices embodied in the Budget Reform Act of 1992, receipts from the Nuclear Waste Fund are no longer designated solely for the purposes of the Nuclear Waste Policy Act but are used to pay for discretionary activities of the Federal government. Therefore the used fuel repository program must compete for funding with other non-Nuclear Waste Policy Act activities undertaken by the Federal government.

Public perceptions of nuclear energy have gone through significant swings since the inception of nuclear power in the 1950s and 1960s. The industry began with widespread support from the public and policymakers. Cost overruns of new facilities and electric rate increases raised concerns, but generally through the early 1970s the public enjoyed the benefits of nuclear energy and the industry sustained a largely positive image. Support began to wane in the early 1970s because of increased concerns over the safety of nuclear energy.

However, a number of factors is leading to a shift in support for nuclear energy, including projections of increased energy demand; increasing concerns over the emissions of greenhouse gases and other pollutants produced by traditional fossil fuel plants and their effect on climate change; increasingly tight markets and high prices for natural gas resources; and the need to maintain a sustainable supply of affordable, reliable, and carbon-friendly fuels. Specifically:

- The desire to reduce harmful air emissions such as $CO_2$, NOx, SOx, and mercury is leading to a reevaluation of nuclear energy as a means to provide baseload electricity without emitting air pollutants or greenhouse gases.
- While safety will always be an essential criterion for the licensing and operation of nuclear power facilities, public confidence in the safety of nuclear energy has grown since the 1970s because of the industry's steadily improving safety performance.

## *CECA Forum Findings on Nuclear Energy*

The CECA Forum found that nuclear energy is an important component of the current electric power sector, and has the potential to become a larger part of the fuels portfolio in the next 20 years and beyond once the barriers are overcome. More specifically, the CECA Forum found that:

- Over the next 20 years, the need will increase for affordable and reliable power that does not emit criteria pollutants and greenhouse gases. Nuclear energy is the only proven resource that can accomplish this goal on a large scale.

- The most significant remaining uncertainties for new nuclear power facilities involve capital cost, the regulatory approval process, and the issue of used or spent fuel management. Beyond these uncertainties lay questions of nuclear fuel cycle proliferation and public perceptions concerning safety.

- Despite efforts of industry, the Federal government, and other nuclear advocates, the development of the Yucca Mountain repository remains controversial. Therefore, it will be important for DOE and the NRC to make near-term progress and complete the licensing process for Yucca Mountain as a used nuclear fuel repository while not compromising safety concerns or public participation in the process.

- Of all the options for used nuclear fuel management, an optimal system incorporates a combination of short- and longer-term measures, including direct disposal, interim storage, and eventual recycling once proliferation risks are successfully addressed.

- Even though support for nuclear energy appears to be growing, it is essential that the public and policymakers receive clear, impartial, and balanced information so that the risks and benefits of nuclear energy can be assessed based on objective analysis and decisions can be made.

## CECA Forum Recommendations on Nuclear Energy

CECA's recommendations on nuclear energy are based on the CECA Forum's recognition that nuclear energy can provide an abundant supply of electricity at stable costs while producing no greenhouse gas emissions or other pollutants during generation. The recommendations are designed, among other goals, to ensure the safe and effective disposal of used nuclear fuel, to ensure the availability of R&D funding for advanced reactor designs, and to build support for objective third-party public information on nuclear issues.

10. *CECA recommends that DOE and the U.S. Department of the Treasury expeditiously implement aspects of the Energy Policy Act of 2005 that support accelerated expansion of nuclear energy, including implementing the standby support, loan guarantee, and production tax credit provisions of the Act. Priority actions should include providing resources to complete the standardized first-of-a-kind engineering and demonstration of three advanced nuclear designs, which incorporate enhanced safety and reliability features, as well as resources to support early site permitting and combined license demonstrations.*

11. *In recognition that an optimal used nuclear fuel management system should incorporate a combination of short- and longer-term measures:*

    - *CECA recommends that DOE implement surface or near-surface interim storage measures to enable storage for a period of 50-100 years at secure federally regulated sites and that NRC and Congress evaluate the need for implementing regulations.*

    - *CECA recommends that DOE and the Congress take the necessary steps to initiate the use of Yucca Mountain as an In-Repository Monitored Retrievable Storage Facility.*

    - *CECA recommends that DOE and the NRC expedite the licensing of Yucca Mountain as a used nuclear fuel repository while not compromising safety concerns or public participation in the process.*

12. *CECA recommends that DOE undertake an R&D program focused on advanced nuclear fuel cycles, including advanced reactor designs capable of burning the long-lived components in used nuclear fuel.*

13. *CECA supports the concept of a new nuclear fuel supply and spent fuel take-back regime. CECA further recommends that DOE and the U.S. Department of State press for significant strengthening of the non-proliferation regime, and continue to discourage excess inventories of separated plutonium worldwide. Specifically, the U.S. should work with individual countries and with the International Atomic Energy Agency to protect against theft of nuclear material and the clandestine use of enrichment and reprocessing facilities for weapons development, as well as improvement of capabilities to detect diversion of nuclear materials.*

14. *CECA recommends that Congress remove the Nuclear Waste Fund from the Congressional budget process, so that all monies currently in the Fund and those to be collected in the future from ratepayers are allocated solely for the purpose of developing interim and long-*

*term storage and disposal of nuclear waste, along with associated transportation systems.*

15. *CECA recommends that DOE support activities to provide the public and policymakers with clear, impartial and balanced information so that the risks and benefits of nuclear energy can be assessed and decisions made based on objective analysis. The public education efforts should address issues relating to the safety profile of current generation technology, security and non-proliferation measures being undertaken, nuclear energy's profile as a greenhouse gas-emissions-free resource, and short- and longer-term options for the safe storage of used nuclear fuels. CECA further recommends that DOE support the efforts of objective, third-party organizations to undertake such public education efforts.*

## *Renewable Energy Resources*

Concern over global climate change is one of the key drivers in the decision to deploy renewable energy resources, energy efficiency, and other non-carbon emitting technologies. A legislated carbon constraint policy would affect the technologies associated with renewable energy. Whatever form future Federal climate policy takes, it is clear that technology development in renewable energy and energy efficiency is critical to achieving a zero- or near-zero emissions future. Among the most important issues in developing the nation's renewable energy resources are the role of the government in mandating the development of these resources (the Renewable Portfolio Standard (RPS) debate), research designed to improve the economics and overall performance, and the integration of renewable energy into the electricity grid.

### Renewable Portfolio Standards

Renewable energy resources include hydroelectric power, biomass, wind power, solar power, ocean thermal, and geothermal technologies. Renewable energy resource technologies are among the fastest growing segment of the energy sector. Renewable energy resources provide American consumers with clean, domestically available energy. However, until there is greater market penetration of renewables, some of the most promising renewable energy technologies will remain costly. The price of electricity from some renewable energy sources can be among the highest of the energy fuels. In addition, renewable energy is not uniformly available across the nation. Some regions have more renewable potential than others and some regions have potential for greater diversity among the various renewable technologies. Solar power, for example, is best located in the Southwest and other sun-rich areas, while wind power has good locations in the upper Midwest and in offshore locations. Many States have taken an active role in developing their available renewable energy resources with programs tailored to their specific resources and needs.

One of the most significant public debates concerning the development of renewable energy resources is the question of implementation of an RPS. An RPS refers to a mandated minimum amount of generated electricity to be derived from renewable energy sources. Twenty-two States and the District of Columbia currently have some form of an RPS. These mandates differ widely in recognition of the State's needs and resource attributes. Even the definition of what constitutes a renewable energy resource differs, with some States not recognizing hydroelectric power as a renewable energy resource while others include coal waste or efficiency gains from CHP as renewable energy resources. The amount of the renewable mandate also differs, with the more aggressive programs setting renewables at 20 percent of a State's energy portfolio as the goal. Most programs require that the level of renewables increase over time.

In many States, a central feature of an RPS is the allocation of renewable energy credits (RECs). A credit is a tradable certificate of proof that a unit of electricity (i.e., one kWh) has been generated by an approved renewable energy resource. The credits are the proof that the electricity provider has met its RPS obligations. The tradable aspect of the credit allows generators to decide whether to invest in renewable energy projects and generate their own credits, to enter into long-term contracts to purchase credits or renewable power along with credits, or simply to purchase credits on the spot market.

At this time there is no national RPS requirement. Proponents argue that a mandate is necessary to overcome market barriers. Others argue that such a requirement would add costs to consumers' bills and could result in a transfer of wealth from regions of the country rich with renewable energy resources to those with less.

### Hydroelectric Power

Hydroelectric power represents a unique renewable energy opportunity. In a number of States that have developed an RPS program, this resource is not included and some States only recognize energy derived from small scale projects. There is a significant potential for increased hydroelectric power in this country. According to a 1998 study conducted by DOE, 21,000 MW of new hydropower capacity is available at current hydropower projects and non-hydropower dams.

The bulk of this power (16,700 MW) is available by adding hydropower projects at existing non-hydropower dams while the remainder (4,200 MW) can be achieved through efficiency improvements and upgrades of existing projects.

Since 1998, DOE has continued to evaluate potential growth in the hydropower sector. A January 2006 study by DOE's Idaho National Laboratory reports that 30,000 MW of potential hydropower remains untapped in the U.S. in the form of small hydropower, hydrokinetic and hydropower at non-hydropower dams. In fact, DOE has reported that hydropower could double its current contribution.

## Integration and Interconnection of Renewable Energy Resources into Regional Electric Grids

Electric utilities must meet widely varying loads that change each day and from minute to minute. Most utilities provide electricity from a mixture of generating resources, some of which can follow the load up and down, and some of which cannot. Hydroelectric power, geothermal, and biomass are all dispatchable and capable of meeting load profiles of utilities. Wind and solar power present the challenge for utilities of matching loads when the actual power output is harder to predict.

A number of studies have looked at the costs of integrating larger amounts of intermittent resources into specific utility portfolios. The costs come from the additional operation of other generators to control the system and follow load. Studies have found widely differing costs, depending on a region's resource portfolio and level of renewable energy resource penetration. These costs are likely to grow as more utility-scale wind and solar power is added to the grid.

Where renewable energy resources are small or located in remote areas, regulators face the difficult problems of both trying to decide what is the economically optimal mix of renewable generation that should be supported by transmission investment and how to develop a mechanism by which additional transmission facilities could be built and paid for. Who should bear the risks of this development, and how can these risks be mitigated? How large a region should be scanned to analyze the optimal mix of renewable energy and transmission investment?

Recognizing that many of the integration and interconnection challenges for renewable energy resources are region-specific, there are policy actions that should be considered to improve renewable energy integration and increase the amount of transmission investment designed to interconnect remote renewable resources, particularly wind and solar resources, to the grid.

### *CECA Forum Findings on Renewable Energy Resources*

The CECA Forum recognized that renewable energy resources are among the fastest growing segment of the fuels portfolio. They are currently, however, a small part of the overall stationary energy portfolio and even at their current growth rate, the percentage of renewable energy resources in the portfolio by 2025 will still be relatively small compared to projections for fossil fuels and nuclear energy. However, the CECA Forum found that opportunities for new developments in renewable energy resource technologies are positive for the nation because of the economic, national security, and climate-friendly nature of renewable energy resources. More specifically, the CECA Forum found that:

- States can play a key role in developing their renewable energy resources that match their specific needs, thereby complementing Federal government support. However, even with States taking the lead on renewable energy policies, the Federal government must provide adequate financing for research and development of emerging renewable energy resource technologies.
- Research and development for promising renewable energy technologies is essential to maintaining the growth and progress renewable energy resource technologies have made in the past decade.
- Renewable energy resources are an important tool for meeting stationary energy needs in accordance with the National Consumer Priority of environmental responsibility. Renewable energy technologies will also become an increasingly important resource for addressing climate change.
- Adding substantial renewable energy resources to the nation's electricity grid will require overcoming challenges in transmitting the power from remote locations and interconnecting intermittent renewable resources, such as wind and solar power, to the national transmission system without compromising the integrity of the grid.
- Increased emphasis on energy storage methods and associated technologies will strengthen the role of intermittent renewable energy resources in the electricity sector.
- Renewable Portfolio Standards continue to be successfully developed and managed at the State level.
- The hydropower industry is primed for responsible growth. There are important opportunities available to expand the nation's hydropower base while providing responsible environmental stewardship.

## CECA Forum Recommendations on Renewable Energy Resources

The CECA Forum understands that renewable energy is a growing resource in the nation's fuels portfolio. It is an environmentally friendly energy source that has strong potential for the future. Enabling greater supply and promoting increased demand will lower the lifecycle costs of different renewable energy technologies, thereby making them more competitive with conventional energy sources. By increasing research, development, demonstration, and deployment (RDD&D) of renewable energy technologies, removing interconnection barriers, and implementing renewable-friendly rate structures, consumers can be served by the optimal renewable energy technology for their location and circumstance.

16. *CECA recommends that Congress pass legislation which outlines a major national commitment to increased deployment of renewable energy resources, via a framework which:*

    - *Encourages States to consider developing a plan for renewable energy resource development and increased energy efficiency investment. The plan should include an evaluation of the State's renewable energy resources and efficiency programs, State priorities on the use of R&D funding, and the means by which the State would encourage renewable markets and increased efficiency. This should include, but not be limited to, infrastructure development, creative public-private partnerships, and any State requirements pertaining to renewable energy resources, as well as reliability, environmental siting issues, and interconnection issues;*

    - *Creates a national fund to provide support to States in promoting aggressive progress towards deployment of renewable energy and energy efficiency infrastructure, market development, and research. The fund should support development and implementation of State plans discussed above as well as broad-based technology research. Criteria for the allocation of the funds to the States should be developed by DOE through a public, collaborative process involving a broad group of stakeholders and should be designed to allow for the participation of all generators, including municipal utilities and rural electric cooperatives; and*

    - *Encourages State cooperation in interstate trading of renewable energy and energy efficiency credits to allow for interstate sale of renewable energy.*

17. *CECA recommends that R&D funding necessary to identify, develop, demonstrate, and deploy breakthrough technologies applicable to renewable energy sources, such as nanotechnology applications to solar energy, be elevated in national priority.*

18. *CECA recommends that the States, either working bilaterally through Regional State Committees or through organizations such as the National Association of Regulatory Utility Commissioners, resolve issues such as interconnection rules across State lines and interconnection to facilitate usage of more intermittent renewable energy resources.*

19. *CECA recommends that Congress expand FERC's authority under the Federal Power Act to devise cost recovery mechanisms whereby investors of small, clustered renewable energy resources or renewable resources in remote locations can share reasonable cost allocation of such investment with ratepayers after a transparent stakeholder process that includes a hearing and comment process in which the costs and benefits to consumers are carefully considered and it is determined that consumers will benefit. CECA also supports alternative mechanisms that might be developed by individual States to provide such support.*

20. *CECA recommends that Congress act to fully implement the incentives for hydropower production and research and development contained in the Energy Policy Act of 2005. In addition, Congress should extend the placed-in-service date for the Section 45 production tax credit for hydropower to 2015, expand the credit to include hydropower development at non-hydropower dams, and fully fund the hydropower incentive payment and research and development provisions.*

21. *CECA further recommends that Federal and State policies encourage the development of small hydropower facilities and emerging hydropower technologies.*

## Energy Efficiency

Energy efficiency is an essential element in meeting the nation's future energy needs. The concept of energy efficiency encompasses a variety of programs, codes, requirements and energy use behavior patterns. Consumers – from large industrial consumers to residential consumers – have benefited greatly in the last few decades by implementing energy efficiency programs that have resulted in lower end-use costs, higher reliability rates, reduced use of finite fossil fuels, and consequent reductions in greenhouse gas emissions and other pollutants.

Although energy efficiency investments for electricity and natural gas end uses are often highly profitable, a range of obstacles prevents them from being adopted. This appears to be paradoxical, as economics would dictate that rational actors will invest resources to achieve savings where they are cost effective. In practice, however, markets present an array of barriers which result in suppressing energy efficiency below optimal levels.

Decoupling utility revenues from throughput is a key element for efficiency to remove the link between revenues and sales so that sales decrements from efficiency do not negatively impact revenues or profits. California has had such a mechanism in place for decades, and Oregon entered a similar tariff arrangement with Northwest Natural recently. CECA supports designing ratemaking mechanisms in which utilities' costs are recoverable, even though sales volume is reduced because of efficiency or demand-side programs.

Increasing the nation's energy efficiency should not be the sole responsibility of the utilities. Many States have moved ahead of the Federal government in promoting energy efficiency measures and much can be learned from these State efforts. California, Vermont and Iowa are examples of States which have taken progressive and effective steps to incorporate energy efficiency programs into their overall State energy resource plans. The Federal government should be mindful of these programs and ensure its policies are not inconsistent with State programs and plans.

In addition to domestic energy efficiency programs, American consumers benefit from international energy efficiency efforts, through reduced demand and thus reduced prices for energy fuels and reduced global emissions. The U.S. should play a leadership role in encouraging energy efficiency internationally and take the lead in energy efficiency technology development. Additionally, the U.S. should lead efforts to provide technological assistance to developing nations. DOE efforts in providing such technical assistance can be greatly expanded.

Among the most significant policy directions that can be taken to encourage additional energy efficiency are appliance efficiency standards and building codes, Energy Efficiency Resource Standards (EERS), and regulatory reform policies to separate utility revenues from energy sales throughput. The EERS approach sets performance targets and charges program operators with designing the most cost-effective programs to reach those targets. The Energy Policy Act of 2005 calls for a DOE study and authorization of a pilot program to assist five or more States to test this approach. CECA fully supports this mandate and encourages DOE to move forward with this requirement.

Appliance efficiency standards have already saved American consumers over $50 billion and are estimated to save almost $200 billion through 2030. The Energy Policy Act of 2005 requires the adoption of a number of additional standards and there are a series of requirements that existed prior to the Act that have not been implemented. The requirements in building codes are largely responsible for the substantial drop in heating and cooling energy use per square foot in residential buildings over recent decades. Yet because building codes continue to be a State and local issue, adoption and enforcement of these energy codes remains very uneven across the U.S. The Energy Policy Act of 1992 mandated States to consider adopting the International Energy Conservation Code (IECC).

## CECA Forum Findings on Energy Efficiency

Reducing the amount of fuels consumed to meet the nation's energy needs through energy efficiency measures is consistent with each of the National Consumer Priorities. The CECA Forum recognized that efficiency measures will allow the nation to make better use of the diversified fuels portfolio and efficiency can and should play a major role over the 2025 timeframe of the CECA study. More specifically, the CECA Forum found that:

- There is substantial room for improvement in using fuels efficiently and efficiency measures can play a considerably larger and more effective role over the next 20 years.
- State building codes are proven to reduce the amount of energy needed for heating and cooling, but adoption and enforcement of energy codes remains very uneven across the U.S. absent national building codes.
- Among the most significant policy directions that can be taken to encourage additional energy efficiency are greater emphasis on appliance efficiency standards, building codes, and Energy Efficiency Resource Standards (EERS).
- Decoupling utility revenues from throughput is one option for reversing the disincentive for utilities to encourage energy efficiency measures. Regulated States have other options available that can have equal results.

## CECA Forum Recommendations on Energy Efficiency

CECA's recommendations are based on the CECA Forum's support for increased energy efficiency as a means of reducing the consumption of fuels while meeting the full range of National Consumer Priorities established by the CECA Forum. The recommendations support tighter energy efficiency regulations as well as rate reforms designed to provide incentives to utilities to promote energy efficiency.

22. *CECA recommends that the Federal government implement the following energy efficiency measures and methods:*

- *Promote regulatory reform to achieve decoupling of utility revenue from energy sales throughput so that energy efficiency investments by the utility sector are more attractive to both consumers and utilities;*
- *Accelerate the Energy Efficiency Resource Standards (EERS) approach to energy sales growth by implementing the study provision included in the Energy Policy Act 2005 and developing a national policy;*
- *Promote a more stringent national building code standard by upgrading to the latest International Energy Conservation Code, learning from leading voluntary building standards initiatives to incorporate new energy efficient technologies into design and construction practices. In the interim, CECA recommends that State and local governments adopt the 2006 International Energy Conservation Code, maintained by the International Code Council, as the minimum standard for new and renovated residential and commercial buildings.*
- *Rapidly complete DOE's current list of pending appliance efficiency standards and develop and enforce the 16 new standards mandated in the Energy Policy Act of 2005.*
- *Fully fund increases in energy efficiency RDD&D programs as authorized in the Energy Policy Act of 2005.*
- *Extend consumer, business, and manufacturer energy efficiency tax credits provided in the Energy Policy Act of 2005 beyond the current expiration date to 2010, subject to reauthorization at such point.*
- *Provide full funding for energy efficiency consumer education initiatives authorized in the Energy Policy Act of 2005.*

23. *CECA recommends that States and State Public Utility Commissions implement the following measures to support energy efficiency:*

- *Create ratemaking mechanisms that allow utilities to recover the costs of serving consumers, regardless of the volume of electricity sales.*
- *Require distribution utilities operating in markets with retail competition to procure energy efficiency and renewable energy resources when conducting procurements for default generation service.*
- *Create specific energy savings targets for utilities as a percentage of either forecast load growth or sales.*

## Cross-Cutting Policy Issues

In addition to examining the specific fuels and technologies outlined above, the CECA Forum addressed several cross-cutting policy issues that affect the nation's decisions with regard to implementation of fuels and technology policies over the next 20 years. These issues affect all fuels and therefore were considered within the context of all fuels. The CECA Forum addressed the following cross-cutting issues:

- ***Energy research and development programs*** to ensure that the nation's energy needs are met in ways that optimize the benefits of all fuels. These R&D programs cut across all fuels and all technologies.
- ***Upgrading the nation's energy infrastructure*** to accommodate the expected growth in energy demand. Upgrading the infrastructure requires ensuring a healthy fuels transportation system; modernizing the nation's electric transmission system; ensuring the skilled workforce required to design, build, and operate complex energy systems; and protecting the infrastructure against vulnerability.
- ***Interdependencies of energy system needs and water availability*** promises to be one of the most far-reaching and least recognized issues affecting the ability to provide reliable power through the 2025 timeframe of the CECA study. Energy production uses more water than all other industries and is comparable to agriculture's use of water. Severe shortages of water will have dire consequences on energy systems.
- ***Issues relating to the nation's future carbon policy*** affect all fuels and technologies. Technologies and policies are examined to steer the nation on a path to reducing carbon intensity and greenhouse gas emissions. The goal is to ensure that future energy needs are met in ways that are environmentally responsible and that future generations inherit a sustainable planet.

The CECA Forum also addressed the role of government in ensuring that consumers receive the social, economic, and environmental benefits they expect from the energy system. Government policies stimulate research, development, and deployment of new breakthrough technologies that bring down the high capital costs of clean energy technologies and make them economically competitive. Government establishes regulatory structures and market rules to protect consumers and government is charged with the power to impose penalties to ensure compliance.

### *Energy Research & Development*

Affordable clean energy technologies will be the backbone of any national or international attempt to reduce greenhouse gas emissions significantly. Government has a responsibility to (1) address national and economic security concerns associated with energy R&D and deployment of new technologies; and (2) intervene when the immense cost and business risk associated with deployment of new environmentally responsible fuel technologies is greater than the private sector can bear and is deemed to be in the public interest.

In spite of these needs, since the 1970s public and private funding of R&D for energy technologies has been in steady decline. This trend is not unique to the U.S. Funding for energy R&D in the European Union as a proportion of total R&D has declined from a high of approximately 50 percent in the 1980s to 14 percent today. Unfortunately, the existing method of appropriating Federal funds disadvantages energy R&D as other more urgent priorities outweigh R&D needs. The focus on near-term priorities is mortgaging the nation's energy future.

Since the benefits of many energy R&D efforts may not be ripe until 2020 or later, government and industry have been engaged in identifying affordable technologies with the greatest potential to improve the performance, cost, and environmental attributes of fuels. Current energy R&D is implemented through Federal, State, university, and industry programs. Policymakers have acknowledged the need for more coordination in R&D and stronger adherence to a strategic focus.

### *CECA Forum Findings on Energy Research & Development*

The CECA Forum found that to optimize the nation's fuels and technologies, the government must make a major commitment to fund research and development of energy systems so that the National Consumer Priorities can be met in the near and long term. More specifically, the CECA Forum found that:

- Government has a responsibility to address national and economic security concerns associated with energy R&D and deployment of new technologies. Yet, since the 1970s public and private funding of R&D for energy technologies has been in steady decline.
- Without breakthrough technologies affecting efficiency or costs, clean energy technologies will not be widely deployed.
- There are a variety of models for alternative funding mechanisms in the Federal government and in the States, including dedicated funding from receipts, projected revenues from energy sales, and Public Benefit Funds. Each mechanism has strengths and weaknesses.
- Funding for essential R&D is hampered by the practice of funding Congressional earmarks.
- Since benefits of today's energy R&D efforts may not be realized for decades, funding for more immediate priorities results in decreased dollars for energy R&D.
- Current energy R&D is implemented through a variety of Federal, State, university, and industry programs. More coordination in R&D activities and adherence to a strategic focus is needed.

### *CECA Forum Recommendations on Energy Research & Development*

The CECA Forum recognized that the government has a critically important role to play in energy R&D. CECA's recommendations ask Congress to make funding for energy R&D a national priority in an effort to optimize the performance and positive attributes of each fuel used to meet the nation's stationary energy needs.

24. *CECA recommends continuation of the incentive provisions of the Energy Policy Act of 2005 for production tax credits and investment tax credits, Clean Energy Bonds, and loan guarantees as appropriate to support market adoption of clean energy technologies, including clean coal technologies, nuclear energy, wind, solar, hydropower, and other renewable resources, and energy efficiency. CECA further recommends that Congress extend the duration of these incentives to allow predictability when planning these investments.*

25. *CECA believes the challenges of meeting the nation's future energy requirements in accordance with the National Consumer Priorities of affordability, environmental protection, reliability, and security require a major national commitment to research and development into a broad array of energy fuels, energy efficiency mechanisms, and energy technologies. CECA therefore recommends that Congress make funding of such programs a national priority. This national commitment should be targeted to research and development programs that:*

- *Lead to the next generation of advanced clean energy technologies;*
- *Improve the environmental and efficiency performance of existing energy systems;*
- *Expand the potential applications for existing technologies to address other critical energy needs.*
- *To overcome historic funding deficiencies for energy research and development, CECA further recommends that Congress explore alternative means of funding research and development to allow for significantly larger research investments and more predictability in undertaking multi-year research initiatives.*

## *Upgrading the Nation's Energy Systems Infrastructure*

Ensuring that the nation's future energy needs can be met in ways that are consistent with the National Consumer Priorities involves more than improving the energy fuels and technologies themselves. It also requires improvements to the infrastructure upon which the energy portfolio relies. Much of the energy sector is heavily dependent upon the transportation sector and projected constraints in that sector will become impediments to meeting the nation's energy goals. In addition to physical improvements to the energy infrastructure, there is a critical need to develop the manpower skills required to design, build and operate the complex energy systems.

### Fuel Transportation by Rail and Barge

As the nation prepares to meet increased energy demand, a key consideration must be the ability of the infrastructure to move that energy from its source to its market. Rail and barge transportation of fuel supply constitute the number one and two transport means for delivering coal to electrical generators. Not all new generation is sited in a location served by more than one railroad or on navigable waterways. Currently approximately 30 percent of total coal-generating capacity comes from coal-fired power plants that are served by a single railroad transporter. It is clear that captive rail customers pay a higher price for the delivery of coal than do those who are served by multiple rail carriers. Whether this disadvantages the customer is a topic of debate. A higher price paid for shipping is clearly a concern for captive rail customers, however, in some cases, there are compensating factors. For instance, the increase in shipping costs may be outweighed by a favorable facility location or other workforce, resource, or economic factors. As of 1999, seven of the top 10 lowest-cost coal generation plants were served by only one railroad.

Demand for rail freight is increasing due to the state of the economy and the fuel efficiency of railroads relative to trucking. Railroads must invest significant capital in order to remove bottlenecks and improve throughput to meet this growing demand. It is estimated that freight traffic will grow by more than two-thirds by 2020. Class I railroads will spend more than $8 billion in 2006 on capital expenditures, a 21 percent increase over 2005. Even more investment will likely be needed to keep pace with the increasing demand.

Beyond rail, barge is the second most significant transportation means for moving fuel, primarily coal supplies. Regulators and industry experts anticipate that commerce over the nation's waterways will more than double by the year 2025. The American Waterways Operators estimates that barges "safely and efficiently move fully 15 percent of the nation's freight for less than two percent of its total freight bill, saving shippers and consumers more than $7 billion annually compared to alternate transportation modes." Unfortunately, this valuable system of waterways is in dire need of repair and improvement, but Federal monies have not been appropriated and other monies available have not been used.

### Modernizing the Nation's Electric Transmission System

CECA recently undertook a major analysis of the nation's transmission system and supports the need for the nation's energy planners to identify and plan for the proper expansion of the system. Modernization of the interstate electric transmission system is needed to facilitate efficient regional delivery of wholesale power and maintain regional reliability. A regional transmission highway system will facilitate efficient wholesale markets, which should reduce price volatility, permit the retirement of older, less environmentally-friendly generation facilities, and improve national security through system redundancy.

The most critical infrastructure investment is the construction and use of the high voltage electric transmission system throughout the nation. Undertaking a project to build and operate a high voltage electric transmission line requires the cooperation and approval of numerous regulators, financial investors, and community participants. Owners and investors make investment decisions based on the risk of a project being completed in a timely manner and operated profitably. One of the greatest risks related to investing in transmission is regulatory uncertainty. This uncertainty includes conflicting Federal and State regulations as well as a lack of appropriate policy mechanisms. Congress has attempted to resolve jurisdictional conflicts in the Electricity Title of the Energy Policy Act of 2005 and DOE, FERC, and the States have begun to implement the provisions mandated by the Act.

## Liquefied Natural Gas Infrastructure

Many energy analysts are projecting a need for increased imports of liquefied natural gas to meet future U.S. natural gas demands and to retain in this country U.S. industries dependent on natural gas for process applications. Others believe that siting and safety concerns, balance of payments issues, dependence on foreign sources of supply, and security and cost considerations will limit the importation of LNG. If those issues can be satisfactorily resolved and if LNG is to play an important role, significant investments in new LNG terminals, pipelines, and other infrastructure will be required.

## Maintaining a Skilled Energy Systems Workforce

The workforce required to meet the nation's energy challenges through 2025 is aging and in short supply. The number of students entering engineering and related fields of study necessary to design, construct and operate the nation's complex energy systems is inadequate to meet projected demand. A study by the National Petroleum Council noted, for example, that without quick action, impending shortages of qualified personnel are expected to hinder the ability of the producing sector to find and develop required gas supplies.

The skills shortage is not limited to oil and gas, but permeates the utility sector, in which nearly half of the workforce is over the age of 45. Declines in enrollment in undergraduate petroleum engineering and geosciences' degree programs were 77 and 60 percent, respectively, between 1985 and 1998. While enrollments in nuclear departments have been steadily increasing in recent years, the pace of graduating engineers is outstripped by the anticipated need.

## Infrastructure Vulnerabilities

The nation's stationary energy infrastructure has evolved into a remarkably complex and interdependent network of pipelines, transmission wires, and multi-fueled generating stations to deliver energy to consumers.

The sequential set of activities that converts energy inputs to value-added outputs results in a complex, interdependent, and potentially vulnerable energy delivery process in which removal of one energy source can jeopardize the proper functioning of others. Under normal operating conditions the system generally works harmoniously. However, disruptions can occur due to a range of factors. These factors fall into three categories: technical/infrastructure; natural disasters such as extreme weather events and earthquakes; and accidental or deliberate human actions. Each of these categories represents potentially serious concerns for energy system managers.

### *CECA Forum Findings on Upgrading the Nation's Energy Systems Infrastructure*

The CECA Forum found that the need to upgrade and modernize the nation's energy systems infrastructure is essential if the nation is to meet its growing dependence on fuels. More specifically, the CECA Forum found that:

- Approximately 30 percent of total coal-generated electricity comes from coal-fired power plants that are served by a single railroad transporter. This situation may result in the captive user paying a higher price for coal than customers of competitive railroads and the higher costs may be passed on to consumers.
- Significant capital investment is needed in railroads to meet growing demand.
- Waterways and barges are in dire need of upgrading and repair so that coal supplies can be moved on the nation's waterways efficiently and cost-effectively.
- Modernizing the nation's transmission system on a regional basis is critical to meeting the increasing demands for electricity. Consumers will be best served if the transmission system is upgraded to increase efficiency and reliability of electricity delivery.
- Having a reliable, robust, modern electric transmission system will help to hedge against system vulnerabilities. To do so, both public and private investment in the transmission system to alleviate bottlenecks and congestion is needed in the near term.
- Energy efficiency investments alleviate consumption at peak times, usually during summer and winter when the grid is most prone to outages. Most outages, including the blackout of August 14, 2003, occurred when the grid was operating at or near peak capacity. Because of system interdependencies, alleviating strain on the electrical system will also limit pressure on natural gas systems.
- Distributed generation – generators located at or near customer loads – provides an added bulwark against outages affecting the electric system and, to a lesser but still important extent, the gas system as well. Highly centralized energy infrastructure is inherently brittle, as a single outage in one area of the system can affect many users. By contrast, a network of small, distributed units may help provide resistance against such a failure.

- If decisions are made to increase imports of LNG to supplement domestic supply of natural gas, investment in additional terminals, pipelines and related infrastructure will be required.

- The U.S. must make a major commitment to science and engineering education and other skill sets so the skilled workforce required to design, build, and operate the nation's complex energy facilities is available.

- While protecting against all vulnerabilities to the energy infrastructure is virtually impossible, many disruptive events can be anticipated. Such events include unusually severe hurricanes, massive blackouts, and sabotage to infrastructure.

- Markets provide a strong incentive for energy companies to procure adequate supplies to meet energy demand. Avoiding disruptions is of paramount importance to companies as disruptions have vital implications for company performance and revenues.

## CECA Forum Recommendations on Upgrading the Nation's Energy Systems Infrastructure

The CECA Forum agreed that the nation's energy systems infrastructure needs significant improvement at all levels. Investment is critically needed in the electricity transmission system and the rail and waterways systems. Adequate infrastructure must be built to accommodate any increased imports of LNG. A skilled workforce must be educated and trained to operate the nation's complex energy systems. The infrastructure must be resilient to disruptions.

26. *CECA recommends that Congress encourage reinvestment of capital for expansion of the railroad system by means of incentives such as investment tax credits, and increased investment at the federal level for waterway enhancement. Congress and the Surface Transportation Board (STB) should encourage railroads to provide more reliable service to their customers and promote increased competition in the railroad industry while ensuring railroads earn sufficient revenues. Finally, Congress should encourage the STB to develop a fair and balanced means of determining reasonable railroad rates to captive shippers, which could include an alternative to the stand-alone cost methodology currently used in most railroad rate cases.*

27. *CECA recommends that, given the significance of the nation's navigable waterways to the provision of low-cost energy to America's consumers, Congress place a priority on the funding, construction, and maintenance of navigable waterways as critical energy infrastructure.*

28. *CECA recommends that FERC and State regulators encourage investment necessary to ensure that the transmission system is robust and can adequately and reliably provide the backbone needed for future fuel supply siting decisions.*

29. *CECA recommends that the Federal government address the infrastructure requirements of the energy industry. These requirements include both manpower needs and materials needs. CECA recommends the establishment of multi-agency programs to support technical training programs as well as address limitations in current materials fabrication and manufacturing capability. The technical training programs are needed to build and maintain talent in basic science education, advanced engineering disciplines, and the skilled trades necessary to design, construct, operate, and maintain such complex energy facilities as nuclear power plants.*

## Interdependencies of Energy System Needs and Water Availability

Increasingly, the interdependencies of energy and water systems and the conflicts among water-use sectors are becoming major constraints to meeting future energy needs. Lack of adequate water availability has been the reason that several power generation proposals have not been approved. Growing tension over the competition for water continues to be one of the major issues in licensing and relicensing hydroelectric projects. Currently, issues relating to water availability for energy systems are resolved on a case-by-case basis with little understanding of the wider implications of those decisions.

Competition for available water supply will significantly increase in the coming decades. Energy production is a major consumer of water, using more water annually than all other industries and competing on a par with the agricultural industry's use of water. Thermal electric power production is a large source of these withdrawals, requiring an estimated average of 25 gallons to produce one kilowatt hour of electricity. Therefore, the average consumer uses more water as an input to their electricity usage than they do for all other purposes. The extraction of energy fuels, including both oil and coal bed methane, also results in significant water withdrawals. Approximately 10 barrels of "produced water" are pumped to the surface for each barrel of oil in the U.S. In total, the U.S. Geological Survey estimates the mining industry withdraws an additional 3.5 billion gallons/day. Clearly, water is a critical input to energy production and competition for available water will be a major factor in future energy production decisions.

Conversely, energy is a critical input to water delivery to consumers. For example, the California Energy Commission estimates that at least 10.2 percent of California's total electricity usage goes towards pumping, treating, and distributing water. That amount is expected to increase as water demand grows and populations shift to the more arid West. Power requirements for treatment of impurities in water, desalination, water reuse, and water pumping for distribution will also grow substantially. As the energy needed to drive these water projects in turn requires substantial water inputs, there is significant incentive for energy planners to utilize more energy efficient water technologies and approaches.

### CECA Forum Findings on Interdependencies of Energy System Needs and Water Availability

The CECA Forum found that the interdependencies of the energy and water systems must be addressed so that both systems continue to provide reliable service to the nation's consumers. More specifically, the CECA Forum found that:

- The critical interdependencies of water availability and the ability of energy systems to operate are not sufficiently understood by policymakers and the public. Energy systems require enormous volumes of water to operate properly and water systems require reliable energy to function. Future policies must consider the implications of the energy and water interdependencies;
- As demand for new energy supply increases between now and 2025, system planners will need to develop and implement new, efficient water use systems to support increased demand. Coordination among government agencies in energy and water-related decision making processes is essential.
- Research and technology developments will be required to address the energy/water system challenges.

### CECA Forum Recommendation on Interdependencies of Energy System Needs and Water Availability

The CECA Forum recognizes that the relationship of water availability to energy production must be urgently addressed. For the period of this study, CECA makes the following specific recommendation with regard to the energy/water nexus.

30. *CECA recommends the expedited funding of the DOE Water/Energy Office mandated by Congress in the Energy Policy Act of 2005 to coordinate energy/water related research and development, and serve as a focal point for interagency issues, working with the national laboratories, the U.S. Department of Interior, and other relevant Federal, Regional, and State agencies to ensure coordinated planning for energy and water needs.*

### U.S. Climate Policy

The subject of greenhouse gas emissions and global climate change between now and 2025, the period of the CECA study, is one of the most important energy issues that policymakers will need to address. Scientists believe there is a link between the warming of the earth's atmosphere, with resulting changes in global climate, and increased emissions of greenhouse gases. Greenhouse gases contribute to the greenhouse effect by trapping energy from the sun's rays in the atmosphere. While most of the world's governments, including the United States, recognize the importance of addressing climate change, their policy approaches differ. Even within the U.S., there are differing approaches to addressing climate change. A number of States have implemented some form of emissions reductions program while the Federal government focuses on a voluntary approach. There is a view by many in industry that the Federal government's climate policy may change. The uncertainty as to when and in what form is causing concern in the investment community, raising risks and costs of the needed energy infrastructure.

Climate change is a serious long-term global issue, with causes and contributors that span all sectors of the economy and all nations of the world. In 2003, the latest year for which data is available, the electric power industry in the U.S. contributed 33 percent of U.S. GHG emissions, followed closely by the transportation sector at 27 percent. Clearly, much progress can be made through the efforts of the electric power sector, although a fully effective solution to the climate change issue will require participation throughout the U.S. economy and throughout the world.

Although the debate over climate change demonstrates widely divergent views on policy approaches, there is little or no difference in the long-term goal of achieving very low or near-zero net emissions. Addressing climate change in a meaningful way will require significant changes regarding the energy technologies and fuels on which the economy relies. This type of change cannot happen easily or immediately.

The Energy Policy Act of 2005 included a number of provisions to encourage the development and deployment of climate-friendly technologies. A limited amount of investment tax credits, up to 20 percent, was provided to encourage the use of gasification technologies in the power sector and Federal loan guarantees of up to 80 percent of the capital costs were authorized for a wide range of clean energy technologies including nuclear energy, renewable energy technologies (hydropower, wind, solar, biomass, geothermal), fuel cells, and carbon capture and storage technologies. In addition, Congress authorized a 10 year R&D program and over a billion dollars for research, development and deployment of carbon capture and storage technologies and recognized the importance of regional partnerships established by DOE to address carbon sequestration across the nation. The DOE's Carbon Sequestration Leadership Forum and the billion dollar FutureGen Project are key initiatives that will be important to achieving near-zero emissions fossil fuel technologies.

The development of a climate policy must recognize the role technology will need to play in meeting the nation's GHG-related goals. It is appropriate for government to encourage the growth of clean energy technologies in which the potential for public good is clear. Clean energy technologies include clean coal technologies, nuclear energy, renewable energy resources, and energy efficiency.

As national policies are developed, criteria are needed to support the interests of consumers. Policy should be cost-effective. Adequate lead time for consumers and industry to adjust to the policy should be provided. Many of the investments for reducing or mitigating GHG emissions will take time to put in place. The burden of action should be distributed fairly to ensure cost to consumers is minimized.

Policymakers must view the issue in the context of an overall energy strategy to ensure climate policy is consonant with national and economic security goals. For example, clean coal technologies that include carbon capture and sequestration would address adverse characteristics of coal and meet energy security and climate goals. To improve the environmental performance of the nation's energy fuels, technologies and policy that address the adverse characteristics of each fuel must be developed.

In addition to environmental and affordability criteria, climate policy involves complex issues of national energy security (i.e., reliance on fuels from unstable regions), economy and jobs (potential reductions in industries producing significant greenhouse gas emissions, coupled with potential increases in industries involved in climate-friendly substitutions), and business planning (uncertainty can translate to higher costs). Greenhouse gas mitigation measures include energy efficiency, the substitution of highly efficient technologies in end-use applications, and technologies to improve the environmental characteristics of each fuel in the nation's fuel portfolio. The consequent reduction in the use of energy, coupled with cleaner fuels, directly translates into reductions in carbon intensity and emissions of greenhouse gases. Policymakers must address the issue of reduced utility revenues resulting from reduced generation due to efficiency investments.

The debate on climate policy centers on whether and when the Federal government should shift from its current voluntary approach to some form of mandatory program and what form such a policy should take. No national energy policy implemented over the next 20 years could have a greater impact on fuels for stationary sector energy needs than a shift in Federal climate change policy. In the short term, the impact for some fuels will be positive and for others it will be negative. In the long term, all fuels will benefit as new policies provide incentives for developing low-emitting and energy-efficient technologies to optimize the characteristics of all fuels.

## CECA Forum Findings on U.S. Climate Policy

The CECA Fuels and Technologies Forum found that the increasing demand for a shift in Federal climate policy is the primary cause of uncertainty within the industry and investment communities. Because the Federal government has not enacted such a shift in policy, more aggressive movement is being generated at the State and Regional levels. This adds to doubt and uncertainty for investors, equipment manufacturers, and ultimately consumers. While the CECA Forum generally agreed on the benefits of having a clear national policy instead of a myriad of State and local regulations, it did not determine when such a policy should be adopted or what form such a policy should take. The findings of the CECA Forum include the following:

- Energy efficiency is a critical tool in reducing greenhouse gas emissions and should be encouraged in State, Regional and Federal policies.
- The costs and benefits of all climate policy options must be carefully weighed by policymakers including consideration of the cost of compliance against the cost of waiting to take actions later.
- Because of the global nature of the climate issue, a concerted international approach is required to achieve optimal reductions in greenhouse gases. All major emitter nations must reduce greenhouse gas emissions. The U.S. should play a leadership role in addressing global climate issues.
- Support for research and development into clean energy technologies for all fuels is an essential element of any climate policy. Such technologies will allow the energy industry to undertake emissions reductions more rapidly and with less

cost. Opportunities are ripe for U.S. industry to market these technologies internationally.

## CECA Forum Recommendations on U.S. Climate Policy

The CECA Forum recognized that climate change is one of the most critical issues affecting the nation's fuels and technology portfolio decisions over the next 20 years. While the CECA Forum did not determine what form such a policy should take or when such a policy should go into effect, it agreed that a Federal climate policy is needed to ensure certainty in the marketplace. It further agreed that a diverse portfolio of fuels is needed to optimize benefits to consumers through the 2025 timeframe of the CECA study. To speed development of these fuels and technologies, the CECA Forum agreed that policymakers should increase funding for RDD&D programs, and end-use efficiency and development of low- or zero-emissions technologies should be a major priority for the United States.

31. *CECA recommends robust implementation of the climate and energy technology-related provisions of the Energy Policy Act of 2005, particularly Titles XVI and XVII and other related provisions, such as clean coal technology, nuclear energy, energy efficiency measures, and renewable energy resources, including hydropower, that will facilitate a broad portfolio of diversified generation resources.*

32. *CECA recommends that policymakers put a priority on the development of low- and zero-emissions technologies through accelerated research, development, demonstration, and deployment programs. Public-private partnerships that manage the costs and benefits of these RDD&D programs should be combined with appropriate incentives available to all segments of the industry to advance technologies into the marketplace.*

33. *CECA recommends that policymakers recognize the significant roles that energy efficiency and the utilization of emissions-reducing technologies in end-use applications can play in reducing GHG emissions and thus include appropriate incentives to utilities to encourage their active involvement in such low-cost means of reducing emissions intensity and emissions.*

34. *CECA recommends that policymakers recognize the national energy security, environmental, and economic dimensions of this issue, develop and apply economic modeling practices to climate policy proposals, and provide incentives for development and use of energy from domestic, GHG-friendly technologies.*

# Fueling the Future:
## Better Ways to Use America's Fuel Options

# Part One

# Fueling the Future:
## Better Ways to Use America's Fuel Options

## CHAPTER ONE:
# The CECA Fuels and Technologies Forum

## 1.0 Purpose and Organization

Today's energy industry is rapidly shifting and constantly adapting to new challenges. The energy industry is under increasing pressure to respond to critical social, economic, and environmental challenges. How these social, economic, and environmental challenges are addressed over the next several decades will have profound impacts on consumers.

It is clear that the growing and cumulative impacts of energy policy decisions will require policymakers to determine national and global priorities for the nation's energy resources. For example, environmental impacts of fuels, undervalued 50 years ago, have become a liability to utilities, electricity generators, and to manufacturing facilities because consumers and policymakers are demanding cleaner air and water. Electric power quality and reliability are more important today for a large number of commercial and industrial processes because digital microprocessors are ubiquitously embedded in industrial systems. Since the terrorist attacks of September 11, 2001, concern has increased over the possibility of future attacks on potentially vulnerable facilities and resultant supply disruptions. All of these new developments force a fresh examination of energy systems from a cost, reliability, environmental, and security standpoint. Additionally, the emerging threat of global warming will challenge industry to reduce systematically the emissions of greenhouse gases (GHG) while maintaining a high level of performance.

## 1.1 The Need for the CECA Fuels and Technologies Forum

The demands of the 21st Century will require the energy industry to become more adaptive and transformative—an increasingly difficult task for an industry in which facilities take years to build and fuels infrastructure takes decades to develop. In evaluating current fuels supply and availability, the Consumer Energy Council of America (CECA) identified an overarching issue for examination: *What policies are needed today to ensure the best mix of fuels to meet the nation's social, environmental, and economic needs 20 years from now?* Many actions have taken place in recent years that will help shape the nation's fuels and technologies mix. Congress recently passed the Energy Policy Act of 2005 (the Act) which outlined several near-term and long-term fuels policies;[1] many States have instituted new resource adequacy programs to determine future fuel use, including the implementation of Renewable Portfolio Standards (RPS); regional planning entities, such as Regional Transmission Organizations and Independent System Operators (RTOs/ISOs), have the responsibility of regional planning which takes into account fuel supply and availability, generation planning and transmission planning; the nation's industry is calling for lower prices and better options based on concern over volatile fuel prices; and consumers continue to demand cost-effective measures that provide fuel choices coupled with advanced technologies that provide the benefits of new products and services.

To determine how to best meet future energy requirements and to develop guidance for policymakers on these critical issues, CECA launched the Fuels and Technologies Forum (CECA Forum). The CECA Forum, comprised of experts representing major stakeholder interests from the public, private, and non-profit sectors, came together to address the urgent need for insightful, objective, and innovative policy approaches to maximize benefits, minimize costs, and ensure the most beneficial mix of fuels to meet the nation's energy needs through the 2025 timeframe of the study. Set against a backdrop of escalating energy prices and a continuing divisive debate in Congress and in the States on the future direction of energy policy, the CECA Fuels and Technologies Forum is the first integrated approach to exploring national fuel use and the impact of policy choices from the consumer perspective.

The benefits of fuels are often counterbalanced by costs, including environmental impacts, security, system vulnerability, and/or price fluctuations. CECA believes that minimizing these costs in the future, through implementation and deployment of new technologies, greater understanding of the interrelationship of various fuels, and appropriate policies, is essential for ensuring that industrial, commercial and residential consumers and power generators continue to be able to choose from a diverse portfolio which maximizes

1 Energy Policy Act of 2005, (Public Law 109-58), signed into law August 8, 2005.

benefits and reduces risks of each fuel. The ability of the United States to compete in a global economy necessitates the need for the nation to maintain its diverse fuels and technologies portfolio and to champion those breakthrough technologies which will bring greater reliability, lower costs, and a cleaner world to all consumers.

## 1.2 Convening the CECA Fuels and Technologies Forum

The CECA Fuels and Technologies Forum is the fourth phase of a multi-year examination of impacts to consumers of the evolving electric power industry. This CECA Forum expanded its review to include fuels for all stationary applications. To put this initiative into perspective, in 2001 CECA undertook a year-long effort to assess the viability of integrating distributed generation into the market. The CECA *Distributed Energy Forum* determined that consumers will benefit from a variety of generation options and, as such, distributed generation should be supported as a complement to the central station model of electric power generation.[2] In 2003, CECA addressed, in depth, broader electric power issues during its *Electric Industry Restructuring Forum*, which examined whether the promises made to consumers in restructuring the electric industry in the early 1990s had been realized. During that year-long project, questions relating to the need to enhance the U.S. transmission system were examined.[3]

In 2004, CECA sponsored its *Transmission Infrastructure Forum*, which addressed issues related to regional transmission planning, the options for enhancing the transmission system, and the impacts to consumers of related factors such as generation retirements, fuel supply, and fuel availability.[4] Recognizing that the nation will need to continue to use all of the fuels in its portfolio through the 2025 timeframe of the CECA study to meet stationary energy needs, the *CECA Fuels and Technologies Forum* was convened to examine ways to optimize each fuel and associated technologies so that consumers will benefit from a diversified fuels portfolio. This report also addresses how the provisions of the Energy Policy Act of 2005 will impact the fuels and technologies issues that the CECA Forum addressed.

2 CECA, *Distributed Energy: Towards a 21st Century Infrastructure*, July 2001.
3 CECA, *Positioning the Consumer for the Future: A Roadmap to an Optimal Electric Power System*, April 2003.
4 CECA, *Keeping the Power Flowing: Ensuring a Strong Transmission System to Support Consumer Needs for Cost-Effectiveness, Security, and Reliability*, January 2005.

## 1.3 CECA Fuels and Technologies Forum Structure and Timetable

### *Structure*

The CECA Fuels and Technologies Forum's deliberations were built upon the considerable experience of a broad range of stakeholders representing business, government, academia and non-profit and non-governmental organizations across the range of energy fuels and technologies. The list of participants is included in the introduction to this report. The CECA Forum was chaired by the Honorable J. Bennett Johnston (D-LA), retired Chairman of the U.S. Senate Energy and Natural Resources Committee. Richard Aiken, Senior Associate of Booz Allen Hamilton, headed a team of technical consultants to the CECA Forum. The Booz Allen Hamilton team provided analysis, drafting, and support for the consensus process. The overall management of the CECA Forum was conducted by CECA President Ellen Berman, with the assistance of Peggy Welsh, CECA Senior Vice President and the CECA staff.

The CECA Forum's deliberations began in mid-2005 with the appointment of a group of experts to serve on a Steering Committee charged with setting the CECA Forum's agenda and determining the specific issue areas that the CECA Forum would examine. A list of the CECA Forum Steering Committee members is shown in Figure 1.

To accomplish its objectives, the Honorable J. Bennett Johnston, Chair of the CECA Forum, appointed three Working Groups, each co-chaired by a public and a private sector leader and comprising: (1) fossil fuels, (2) nuclear energy, and (3) renewable energy, energy efficiency, and climate change. Each Working Group was charged with exploring key issues and developing draft findings and public policy recommendations for consideration by the CECA Forum. Consensus recommendations were developed using a set of criteria from the perspective of end-use consumer priorities and drawing on the latest data from national and international studies. The Working Groups and their specific charges were as follows:

***Fossil Fuels Working Group*** – Co-Chaired by Carl Bauer, Director of the National Energy Technology Laboratory, and Robert Hanfling, President and Chief Operating Officer of KFx Inc., the Fossil Energy Working Group focused on those economic, environmental, safety, and security issues associated with the deployment of fossil fuel technologies to meet projected 2025 energy demands. Among these issues were questions of cost and technical viability of carbon capture; the potential of clean coal technologies; energy infrastructure needs for fossil-based fuel supply; use of petroleum to meet stationary energy needs, including home heating; and the impact of volatile natural gas prices and supply and concerns revolving around the importation of liquefied natural gas.

***Nuclear Energy Working Group*** – The Nuclear Energy Working Group was Co-Chaired by the Honorable Laura Chappelle, Commissioner of the Michigan Public Service Commission, and Angelina S. Howard, Vice President, Office of the President, of the Nuclear Energy Institute. The Nuclear Energy Working Group examined the range of nuclear energy issues facing the nation, including safety; the cost and regulatory uncertainties of construction of new facilities; used nuclear fuel management options; and concerns regarding proliferation. The Working Group developed options for policymakers to resolve these issues will contribute to nuclear energy's ability to optimally support the future energy portfolio.

***Renewables, Energy Efficiency, and Climate Change Working Group*** – Co-Chaired by the Honorable Michael R. Peevey, President of the California Public Utilities Commission, and Robert W. Fri, Visiting Scholar, Resources for the Future, the Working Group examined the obstacles and opportunities facing greater deployment of renewable energy resources and energy efficiency in the nation's future stationary energy portfolio. The Working Group also addressed research needs, efficiency policy options, and options for responding to the issue of climate change.

***Cross-Cutting Issues Addressed by All Working Groups*** – In addition to the specific issues under their jurisdiction, each Working Group also examined cross-cutting issues that apply to all fuels and future technologies. These cross-cutting issues include the appropriate role of government, the need for research, development and deployment of technologies that will optimize the nation's fuels and technology options, infrastructure requirements, and options for minimizing the impacts of each fuel on the environment.

**Figure 1: Organizations Serving on the Steering Committee**

- *The Honorable J. Bennett Johnston, Chair*
- *American Council for an Energy-Efficient Economy*
- *American Electric Power*
- *California Public Utilities Commission*
- *Carnegie Institution*
- *Chevron*
- *Duke Power*
- *Edison Electric Institute*
- *Environmental Defense*
- *Iowa Consumer Advocate*
- *National Association of State Utility Consumer Advocates*
- *National Association of Regulatory Utility Commissioners*
- *National Energy Technology Laboratory*
- *National Oilheat Research Alliance*
- *National Rural Electric Cooperative Association*
- *New Jersey Board of Public Utilities*
- *New York Public Service Commission*
- *New York State Energy Research and Development Authority*
- *Nuclear Energy Institute*
- *Oak Ridge National Laboratory*
- *PQR, LLC*
- *Resources for the Future*
- *RW Beck*
- *Sandia National Laboratory*
- *U.S. Department of Energy, Office of Nuclear Energy, Science and Technology*

## Timetable

To begin its consensus-oriented deliberation process, the CECA Forum Steering Committee established a series of National Consumer Priorities against which fuel use decisions should be measured. The National Consumer Priorities were used to guide the CECA Forum's research and to evaluate the impacts of proposed policy recommendations. The National Consumer Priorities are discussed in Section 1.7.

The Steering Committee also agreed to the phases and timetable of the CECA Forum's work, as shown in Table 1. Phase One of the CECA Forum included conducting in-depth research on the portfolio of available fuels and technologies and assessing the positive and negative attributes of each fuel in the context of the National Consumer Priorities. National and international analyses were examined. The CECA Forum examined the interdependencies of each fuel on one another and on each sector of the economy. The result of this research is discussed in detail in Chapter Six of this report. Phase One resulted in the development of white papers that served as the basis for discussions and consensus building by the multi-stakeholder panel at the First Plenary Session of the Forum on July 20, 2005.

In Phase Two, the members of the CECA Forum broke into the three Working Groups outlined above to identify the five most significant issues pertinent to the fuels and technologies within their respective Working Groups and to develop initial findings and recommendations. The full membership of the CECA Forum discussed the initial issues developed by the Working Groups in the Second Plenary Session held on September 20, 2005. In Phase Three, the Working Groups developed initial policy recommendations which were discussed in the Third Plenary Session held on November 9, 2005.

Finally, in Phase Four, the CECA Forum developed public policy recommendations. At the fourth and final Plenary Session, held on March 1, 2006, the members of the CECA Forum discussed and reached agreements on the policy recommendations and on the draft report. This report, with its findings and recommendations, is the result of the four-phase process.

## 1.4 The Report of the CECA Fuels and Technologies Forum

### *Purpose of Report*

The report of the CECA Fuels and Technologies Forum is designed to serve as a useful guide for policymakers. Policymakers must make difficult fuels and technology policy decisions over the next 20 years through the 2025 timeframe of the CECA study. This report, *Fueling the Future*, identifies and provides background on issues, examines the pros and cons of options to meet the nation's future energy needs, and presents policy recommendations to meet those needs. *Fueling the Future* is an unbiased, comprehensive resource tool on fuels and technologies policies. It will be especially valuable as new and creative proposals, each with a complexity and urgency beyond the resources of many agencies to examine adequately, come before energy officials at the Federal, Regional, State and local levels for their review.

### *Organization of Report*

*Fueling the Future* is organized into two Parts: *Part One* is issue-focused and includes Chapters One through Five. It presents an examination of issues, sets the stage for why the CECA Fuels and Technologies Forum was convened, analyzes current fuels and technologies policies, explores opportunities and barriers for the continued or expanded use of each fuel; examines the pros and cons of new policy options, and presents the CECA Forum's findings, conclusions, and a recommended course of action.

*Part Two*, which includes Chapters Six and Seven, serves as a comprehensive reference tool on available fuels and technologies and examines in depth such technical aspects as costs and benefits of fuels, opportunities and challenges, pollution control technologies, and regulatory drivers. *Part Two* also provides a history of U.S. fuels policy so that policymakers can fully understand how the nation's fuels and technology policies have evolved over time.

*Chapter One* introduces the purpose, scope, and underlying philosophy of the CECA Forum. It presents the framework in which CECA Forum members pursued these critical fuels and technologies issues and explains the National Consumer

**Table 1: Four Phases of the CECA Fuels and Technologies Forum Consensus Process**

| Phase 1<br>Research Fuels and Technologies<br>May – July 2005 | Phase 2<br>Research Fuel Specific Issues<br>July – Sept 2005 | Phase 3<br>Initial Draft Findings and Recommendations<br>Sept – Nov 2005 | Phase 4<br>Review of Final Report<br>Nov 2005 – May 2006 |
|---|---|---|---|
| Planning meeting of the Steering Committee to refine scope of work, develop research agenda, and recommend working groups and leadership.<br><br>Convening of First Plenary Session of CECA Forum to discuss scope and approach.<br><br>**Deliverables:**<br>White papers included:<br>(1) analysis of the projected demands of the stationary sector through 2025;<br>(2) assessment of baseline costs and externalities associated with consumption of each fuel; and (3) history of fuels policy in the U.S. | Convening of Second Plenary Session of the CECA Forum to discuss issues identified by Working Groups.<br><br>**Deliverables:**<br>Identification and development of major issues to be addressed by Working Groups.<br><br>White papers included:<br>(1) vulnerabilities associated with interdependencies of fuels; (2) impact of Energy Policy Act of 2005 on Forum's goals and objectives. | Convening of Third Plenary Session of the CECA Forum to discuss draft findings and recommendations.<br><br>**Deliverables:**<br>Development of (1) draft recommendations and (2) outline of the final report.<br><br>Continuation of consensus-building process for resolving contentious issues. | Convening of Fourth Plenary Session of the CECA Forum to discuss and reach consensus on the public policy recommendations; approve draft report; and discuss roll-out of report before Congress, other Federal agencies, and the States.<br><br>**Deliverables:**<br>Publication of report with recommendations; roll-out of report. |

Priorities which the CECA Forum believes should serve as a basis for meeting future energy needs.

*Chapter Two* provides a data-based assessment of the nation's energy needs through 2025. This assessment is based on the best available national and international studies of current demand and future needs, as well as existing policies and available and known technologies. It assesses how projections of energy demand through 2025 might be affected by the imposition of a federal carbon reduction scenario. It identifies other key indicators, as well, that could dramatically affect the nation's energy future.

*Chapter Three* outlines the key policy challenges confronting energy decision makers. This chapter addresses specific opportunities and barriers for the continued and expanded use of each fuel and associated technologies and presents the pros and cons of policy options.

*Chapter Four* outlines overarching issues that affect all fuels and technologies.

*Chapter Five* provides the CECA Forum's conclusions and recommendations for policymakers.

*Chapter Six* provides an in-depth evaluation of each fuel in the fuels portfolio used to meet stationary energy needs and includes an identification of the costs and benefits of each fuel, as well as a discussion of environmental and other externalities associated with each fuel. Included in this chapter is a comprehensive examination of coal, natural gas, oil, nuclear energy, and renewable resources, including hydroelectric power, biomass, wind power, solar power, and geothermal. Importantly, the chapter also examines the costs and benefits of energy efficiency, which the CECA Forum treats in a similar way to fuels as a resource for meeting future demand.

*Chapter Seven* provides a brief history of fuels and technology policy in the United States. This chapter reviews how the nation's fuels policies have affected the use of fuels and how fuels policy and regulation has evolved over time. This chapter provides the reader with important general background that sets the context in which the current study is undertaken.

## 1.5 CECA's Successful Consensus-Building Process

With over 30 years expertise in formulating energy policy recommendations on the most important energy issues confronting consumers, CECA consistently finds that the most enduring recommendations are forged through consensus-based processes. CECA undertook this initiative recognizing that sound public policy is best developed when stakeholders have an ability to voice their interests, concerns and ideas, debate issues, and come to consensus on a best course of action to guide public policy.

CECA's consensus-building process emphasizes candid, constructive expression of views and information by stakeholders as a means of minimizing partisan and ideological differences. The CECA Forum's consensus-building process remains an essential differentiator between its recommendations and those of trade groups, interest-driven, or other non-profit organizations. Debate and evaluation of competing ideas within a set of criteria defined and agreed to by the participants is undertaken with the goal of coming to consensus. This marketplace of ideas and information allows participants to test various approaches, refine ideas, evaluate problems, and develop viable solutions. As a result, CECA's recommendations incorporate the most up-to-date information and have undergone a rigorous vetting process by national thought leaders representing a broad range of stakeholder interests with an equally diverse range of views. This process helps to reduce significantly many of the political and legal battles that accompany implementation of new policies and legislation.

The recommendations contained in *Fueling the Future* are methodically built using detailed research from leading national and international institutions, a focused consensus-building process among leading stakeholders, and extensive outreach and education on the findings and recommendations of the CECA Forum. Nevertheless, CECA takes full responsibility for the final report and for its findings and recommendations.

## 1.6 The Scope of the CECA Fuels and Technologies Forum: Stationary Applications

The CECA Fuels and Technologies Forum focused its examination on energy needs in the stationary sector, considering its multi-fuel infrastructure and its direct impact on all consumers. CECA recognizes that fuel and technology options for meeting the transportation sector's energy needs are equally important to the security and sustainability of the nation. However, those issues are beyond the scope of this study. They are great enough to require a separate review which CECA will undertake at another time.

For the purposes of the CECA Forum, the three primary sources of energy consumption in the stationary sector are the following:

- ***Power Generation*** – The conversion of fuels to generate electricity constitutes the single largest segment of energy consumption in the stationary sector. This includes generation by public and private utilities, including investor-owned utilities, Federal power authorities, such as the Tennessee Valley Authority, that control generation as well as transmission and distribution (T&D) assets; public power systems and rural electric cooperatives that are dependent on others to provide transmission services, known as "transmission dependent utilities" (TDUs); independent power producers (IPPs) that sell electricity into wholesale electricity markets; and, to a more limited extent, specialized energy services such as combined heat and power (CHP).

- ***Heating and Cooling*** – Many industrial processes burn fossil fuels to generate heating and cooling in manufacturing processes. Residential and commercial buildings require direct use of fuels to provide space heating and cooling. The Northeastern States, in particular, and other regions of the country rely on petroleum-based products to provide heat during the winter.

- ***Industrial Feedstock*** – Industrial processes utilize carbon-based fuels as feedstock for the production of other end-use products. As such, fuels used as feedstock are not consumed for their heat content, as is the case in the production of power. Industries such as petrochemicals rely heavily on feedstock, the price of which can affect the economic viability of the industry. CECA's study considers use of feedstock, because it constitutes a noteworthy dynamic for stationary sector consumption applications.

## 1.7 National Consumer Priorities: The Evaluation Criteria

Recognizing that consumers will be best served through the availability of a diversified portfolio of fuels, the CECA Forum based its evaluation of fuels on the premise that traditional fuels will continue to be used in the nation's fuels portfolio through 2025, the timeframe of the CECA Forum's study. Three key consumer-based assumptions served as the basis for this hypothesis:

- Consumers are best served if there is a robust, dependable energy supply;

- Consumers are best served if there is a diversity of fuels, recognizing each region's unique resource base; and

- The U.S. will continue to need all fuels. Therefore the nation must optimize the portfolio of fuels so that consumer benefits are maximized and risks associated with fuels are minimized.

Using the key consumer-based assumptions, the CECA Forum created a series of National Consumer Priorities as the prism through which CECA Forum members examined and compared the different fuels and technologies. The National Consumer Priorities are:

- ***Environmental Protection*** – Air and water quality, including the impact on global warming, must not be compromised by fuel use in order to ensure the health and well being of all Americans and their environment.

- ***Affordable and Predictable Energy Services*** – Consumers, especially low- or fixed income consumers, must be assured that power is available that is both predictably and affordably priced.

- ***Sustainable Economic Development*** – The national economic engine must run smoothly and continue to grow and compete in the global marketplace while making the best use of available resources.

- ***Reliable and High Quality Energy Services*** – High quality and reliable power is a necessity for many industries, including those industries that rely on fuel as feedstock.

- ***Public Safety*** – Citizens must be protected from any potential harm caused by energy systems.

- ***System Security*** – Energy systems must be sufficiently reliable to withstand disruptions caused by acts of nature or accidental or deliberate human actions. In addition, the importation of fuel resources from international suppliers must not result in negative geopolitical impacts. Finally, energy systems must be effectively interdependent so that when one system is affected; the entire fuels infrastructure is not harmed, costing consumers in lost products and services.

Affordable and predictable energy services form the base of the National Consumer Priorities pyramid (Figure 2). This criterion is a major consumer concern as prices for energy fuels have risen dramatically. Along with price, consumers also most highly value environmental protection. These priorities may sometimes be viewed as conflicting, leaving policymakers with difficult tradeoff decisions. The remaining criteria are important to consumers but do not play as pervasive a role in their day-to-day lives; rather, their importance is demonstrated when significant events

**Figure 2: National Consumer Priorities Pyramid**


*Source:* Consumer Energy Council of America, 2006

occur, such as mining accidents, extreme weather events, or accidental or intentional human actions.

To the greatest extent possible, fuel use in the future will have to contribute toward, not conflict with, these National Consumer Priorities. Because of the benefits each fuel in the nation's fuels portfolio provides, new technologies and mechanisms need to be developed to reduce the negative impacts of each fuel. *Fueling the Future* examines each fuel in the context of these National Consumer Priorities.

## 1.8 How Fuels Measure Against the National Consumer Priorities

Over 70 percent of electricity consumed in the U.S. is generated through the combustion of hydrocarbons—primarily coal, natural gas, and oil—creating nitrogen oxide, sulfur dioxide, and carbon dioxide emissions. The nation's reliance on fossil fuels demonstrates that tradeoffs must be made between convenience, price, and the environment in order to sustain economic expansion.

For instance, coal produces environmental costs but it also provides important benefits. It is affordable and abundantly available. Renewable energy resources, such as hydropower, wind power, solar power, geothermal, ocean thermal, and biomass gasification, are characterized by other kinds of costs and benefits. Renewable energy resources show great promise as low emissions technologies, but siting, footprint, and aesthetics issues, as well as high development costs and limited production capacity, serve as barriers to wider implementation of most renewable energy resources.

A careful examination of diesel technologies demonstrates the tradeoff between costs and benefits. Diesel generators, excellent choices for peak demand and stand-by capacity in the electric power industry, produce 30 percent less greenhouse gas emissions than gasoline-powered reciprocating engines for the same amount of power.[5] However, from an air quality standpoint, diesel engines produce much higher levels of other airborne pollutants, such as particulate matter, sulfur and nitrogen oxides. Clearly, the end goal—whether it is reduction of greenhouse gases or reduction of unhealthy airborne emissions—should be a significant factor in determining how fuels are used in the future and how technologies can improve the characteristics of each fuel.

In the case of nuclear energy, nuclear power plants are capable of generating large and reliable amounts of zero-emissions electricity, but used nuclear fuel resulting from the nuclear energy process must be stored safely and securely. Progress has been slow in implementing the Congressionally-mandated long-term method of storage of used nuclear materials, namely, a repository at Yucca Mountain, Nevada. Thus, no long-term used nuclear fuel storage repository has been licensed to date in the U.S. Issues such as nuclear waste storage, safety, proliferation of nuclear materials, and siting of new nuclear power plants are challenges to the greater use of nuclear energy.

In the home heating industry there are tradeoffs between convenience and cost. Natural gas, for example, can be used in condensing boilers that increase the efficiency of the boilers to extremely high levels. However, consumers need to balance the long-term economic benefits of using

5 Diesel Technology Forum at www.dieselforum.org. On the transportation side, new direct injection turbo diesels for automobiles are even more impressive, gaining efficiencies of up to 50 percent over comparable gas engines. See James Kliesch and Therese Langer, *Deliberating Diesel: Environmental, Technical, and Social Factors Affecting Diesel Passenger Vehicle Prospects in the United States*, ACEEE Report #T032, September 2003.

high efficiency equipment with the fact that the natural gas industry is experiencing supply constraints and record high prices, meaning that consumer prices can spike with little notice. Heating oil and propane have similar tradeoffs. In terms of environmental and cost tradeoffs, the production of biodiesel provides consumers with a choice of a renewable, environmentally friendly fuel for home heating, although it is somewhat more expensive. The availability of high efficiency equipment makes heating oil an important option for residential consumers.

There are many consumer benefits in utilizing a diverse fuels portfolio. Maintaining alternatives as a hedge against rising prices, protection against natural or man-made supply disruptions, and ensuring a healthy environment are only a few of these benefits. However, there is no magic bullet for meeting the nation's stationary energy needs and each fuel comes with its own suite of costs and other externalities. To meet growing demand, the nation must make optimal use of all of its fuel resources. Weighing and properly addressing these costs and benefits will ensure the optimal use of fuels in the diversified fuels portfolio as the nation moves to meet its growing energy demand.

# CHAPTER TWO:
# Projections of 2025 Energy Needs

## 2.0 U.S. Energy Demand and Supply Portfolio: Present and Future

One of the underlying goals of the CECA Fuels and Technologies Forum was to formulate a reasonable assessment of the nation's energy needs through the year 2025. CECA Forum members agreed that having a better understanding of the fuel and technology options projected to meet future stationary energy needs was an essential precondition for making informed decisions today. Conversely, since many of the nation's existing energy infrastructure systems and production facilities have 40 to 50 year life spans, assessing the challenges of the future also means understanding today's energy infrastructure. This chapter provides an examination of the nation's current consumption patterns, together with an assessment of future energy demands.

Projecting energy needs through 2025 is a difficult exercise since there are many variables that will affect the eventual outcome. Even a single new piece of legislation— such as the Energy Policy Act of 2005—could have profound effects on energy systems, fuels infrastructure, and rate of technological development responding to emerging needs. Unanticipated acts of nature can cause major fluctuations in price and supply, as demonstrated by the hurricanes that hit the Gulf Coast in 2005. International geopolitical events can and will impact the United States' fuel supply decisions.

Notwithstanding the variables described above, the projections in this chapter are estimates based on CECA's most reasonable expectations as described in the CECA study, *Projecting Energy Needs for the Stationary Use Sector: An Analysis of the Projected Energy Demand in 2025.*[1] This study analyzed research and analysis conducted by the leading global energy agencies– the Energy Information Administration (EIA), the European Commission Directorate-General for Research, and the Institute of Energy Economics, Japan. Therefore, the data provided herein is based on the most stringently researched data available and that data was used for the CECA Forum's projections. While projections are never exact, the scenario CECA presents herein is meant to serve as a reasonable basis for developing a course forward.

Even with the uncertainty of projecting the future, the CECA Forum determined there were a number of important reasons for undertaking the exercise: (1) Devising an estimate of the nation's projected stationary energy needs established an anchor by which CECA could evaluate current policies to determine their long-term implications; (2) Evaluating long-term projections forced the CECA Forum to think in terms of long-term strategies; (3) Examining why the projections could be wrong in the future compelled the CECA Forum to focus on potential variables that will impact the fuels infrastructure; and finally, (4) Projecting energy needs 20 years into the future helped the CECA Forum envision how new technologies that seem cutting edge today could be part of the mainstream energy infrastructure by 2025. The CECA Forum used a 20 year focus as a foundational element of deliberations. The goal of this chapter is to give the reader a better appreciation of the current and projected energy needs and the issues confronting the nation's policymakers as they plan a course of action to best meet those needs.

## 2.1 Current U.S. Stationary Demand Profiles

The U.S. consumes approximately 71 quadrillion British thermal units (BTUs) of energy to heat homes, operate electrical equipment, undertake industrial processes, and serve other stationary purposes.[2] This consumption represents approximately 70 percent of total consumption in the United States in 2003 (the latest date available for data), with the other 30 percent consumed by transportation needs. Fossil fuels provided the bulk of the energy required for the stationary energy sector. In 2003, 57 quadrillion BTUs – 81 percent – of stationary energy came from oil, natural gas, and coal. Coal constitutes the primary resource in the stationary mix, providing nearly one third of the BTUs consumed for these purposes. Natural gas and petroleum played major

1 Consumer Energy Council of America, *Projecting Energy Needs for the Stationary Use Section: An Analysis of the Projected Energy Demands in 2025*, Washington, DC, November 2005.

2 All estimates for current demand, except where noted, are from the Energy Information Administration's *Annual Energy Outlook 2005*, published by the Office of Integrated Analysis and Forecasting, January 2005. The latest figures available are for 2003.

roles as well, with natural gas providing another 31 percent (22 quadrillion BTUs), and petroleum another 18 percent or 12 quadrillion BTUs (see Figures 3 and 4).

Non-fossil fuel sources provided a smaller, but nevertheless considerable, share of stationary energy needs. Nuclear energy provided nearly eight quadrillion BTUs in 2003, or about 11 percent of all stationary energy consumed. Renewable energy resources, including hydroelectric power, contributed eight percent of all energy consumed for stationary purposes in 2003.

## *Fuel Consumption in the Electric Power Sector*

As seen in Figure 5, electric power comprised over half of all stationary energy consumption in 2003. The majority of electric power is derived from *coal*, with significant contributions from nuclear energy and natural gas. Ninety percent of coal consumed in the United States annually is used for the generation of electrical power, with the result that, in 2003, coal-fired power provided 54 percent (20 quadrillion BTUs) of electricity generation.

The United States possesses plentiful, steady coal resources. High capital costs, lengthy construction periods and environmental concerns associated with coal limited construction of new coal-fired plants in the past decade. These concerns also have caused a transition to coal mined in the American West, which contains lower sulfur content than coal from Eastern deposits.

*Natural gas* supplies 13 percent (5 quadrillion BTUs) of electricity generation in the United States. Because of its clean-burning nature and the relative affordability of plant construction, natural gas has satisfied many of the emerging requirements for electric power. The attractiveness of new gas-fired plants, however, has been significantly reduced due to the steep increases in prices for natural gas experienced over the past few years.

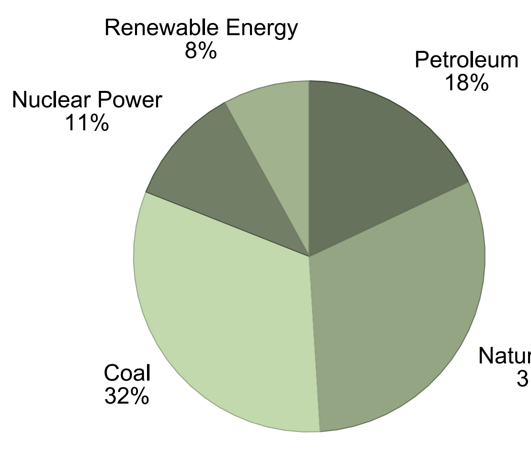
*Oil* represents a relatively modest amount of power generation in the United States: three percent (1.15 quadrillion BTUs). In the stationary sector, oil is used primarily for home heating. Power generation by oil-fired plants has declined substantially over the past several decades following the oil shocks in the 1970s.

*Nuclear energy* represents the second largest portion of total electricity production at 21 percent (approximately eight quadrillion BTUs). While no new nuclear plants have been ordered in the U.S. for nearly 30 years, nevertheless, output from current nuclear plants has increased due to improvements to the existing nuclear power plants as indicated by very high capacity factors (in some years the average U.S. nuclear capacity factor has been in excess of 90 percent.). Interest in nuclear energy has enjoyed a renaissance in recent years as the U.S searches for ways to lower emissions of greenhouse gases, reduce dependence on expensive natural gas, and limit reliance on imported fuels from unstable countries.

The majority of *renewable energy resources* currently supports the electric power sector. The contribution of renewables to the national electricity mix is small (approximately nine percent) and is dominated by hydroelectric power, which accounts for seven of that nine percent.

The use of *hydroelectric power* varies substantially by region, with New York and the Pacific Northwest deriving much more of their energy needs from hydroelectric power than other regions of the country. Hydropower is desirable for its emissions-free electricity and protection to ratepayers from price volatility. Although new hydroelectric projects involve conflicts over increased competition for water that

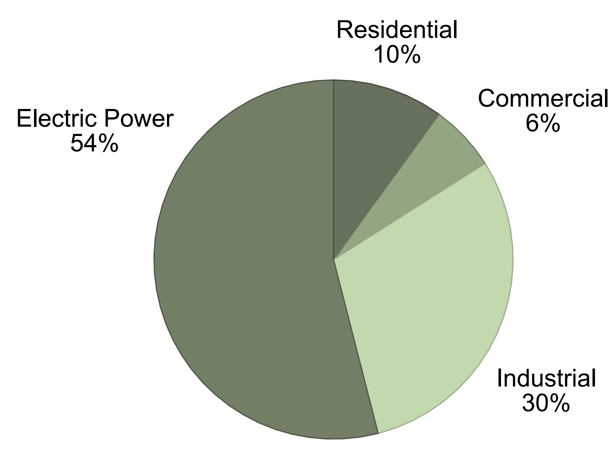
**Figure 3: Stationary Demand by Fuel, 2003**




Total: 70.98 Quads

*Source:* EIA, 2005

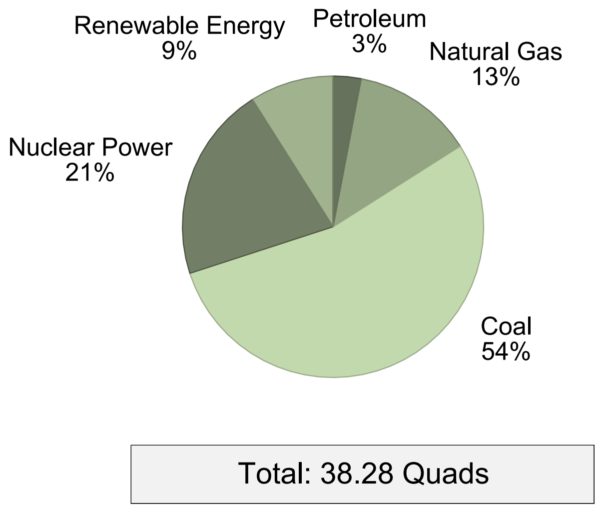
**Figure 4: Stationary Demand by Sector, 2003**




Total: 70.98 Quads

*Source:* EIA, 2005

**Figure 5: Electric Power Sector Consumption, 2003**




*Source:* EIA, 2005

affect natural resource planning, and many of the best sites for large hydroelectric development in the United States have already been utilized, the nation's hydropower capacity nonetheless has not been fully tapped.

A study by the U.S. Department of Energy's Idaho National Laboratory (formerly the Idaho National Engineering and Environmental Laboratory) estimates that about 4,300 megawatts (MW) (approximately 0.05 quadrillion BTUs per year, assuming a 45 percent capacity factor) can be procured merely through efficiency improvements and capacity additions at existing hydroelectric facilities.[3] Retrofitting non-hydropower dams with generators will yield an additional 17,000 MW (0.28 quadrillion BTUs). While these figures are not large in a national context, they would be significant in the regions in which hydroelectric power is most prevalent. In January 2006, Idaho National Laboratory issued its latest report based on additional study. It found that 30,000 MW of hydropower remains untapped within the United States. Nearly 20,000 MW of this energy potential is in Western States that are experiencing rapidly growing populations and energy demands. This power is primarily small hydropower and hydrokinetic development (damless hydropower).

Non-hydroelectric renewable energy resources constitute the fastest-growing sector of the energy economy, although they are developing from a small base. *Biomass* supplies most of the non-hydroelectric renewable power in the United States. Generation capacity totals 9,799 MW, installed primarily at pulp and paper facilities to generate steam and electricity using wood and wood wastes. Biomass has the potential for use in gasification systems similar to that of integrated gasification combined cycle plants (IGCC) for coal. Some of the more interesting developments in the utilization of biomass have come in the form of "biorefining," which refers to facilities that have the capability to convert biomass into fuels, such as ethanol, to generate electric power, and to produce commercial-grade chemicals.[4]

*Wind power* recently emerged as the strongest candidate to provide additional capacity in the United States, and has an installed capacity of roughly 10,000 MW.[5] *Geothermal plants*, which draw energy from underground hot water sources, currently contribute about 2,300 MW of capacity, most of which is located in California. *Solar power* – both photovoltaic and thermal – provides about 397 MW of power to the grid. Solar power is particularly useful in off-grid applications, but it remains prohibitively expensive in all but the most specialized grid-based applications.[6]

Renewable energy technologies are highly dependent on economic and other policy incentives to stimulate their use. Several States have enacted Renewable Portfolio Standards that require a specified percentage of energy delivered by utilities to be derived from renewable sources.[7] Congress has reauthorized for brief periods of time a production tax credit, which is now at 1.9 cents/kilowatt-hour, for defined renewable energy facilities. This has resulted in significant investments in those technologies. The 1.9 cent tax credit was most recently extended as part of the Energy Policy Act of 2005.[8]

## *Energy Consumption in the Industrial Sector*

The industrial sector consumes about 30 percent of all energy used for stationary purposes or approximately 32 quadrillion BTUs. Much of this energy (60 percent) is in the form of *electricity* (see Figure 6); the remainder is used either as feedstock or as process heat.

Beyond electricity, *oil and gas* are the most significant sources of energy for the industrial sector. Industry relies on *petroleum* for use as both a feedstock in the petrochemical industry as well as a fuel for supplying process heat. Variations in the price of oil are problematic for industries that rely on petroleum feedstock because they have few substitutes,

3 Alison Conner, James Francfort and Ben Rinehart. *U.S. Hydropower Resource Assessment – Final Report*, Idaho National Engineering and Environmental Laboratory, Idaho Falls, Idaho, December. 1998.

4 See National Renewable Energy Laboratory Biomass Research site at http://www.nrel.gov/biomass/biorefinery.html. accessed on March 7, 2006.

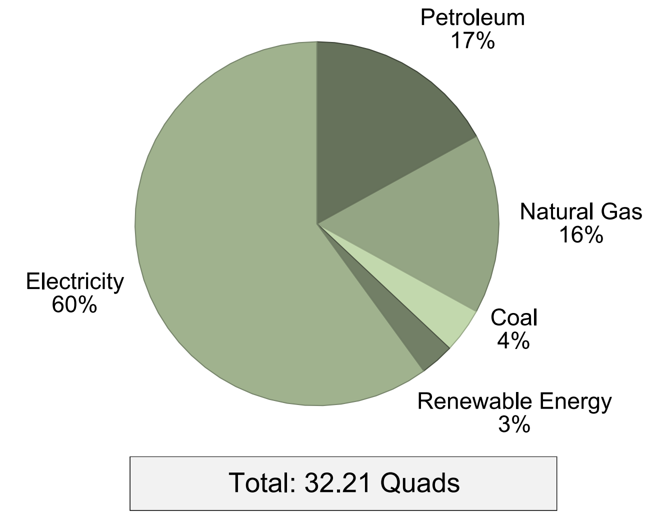
5 American Wind Energy Association, "Wind Energy Fact Sheet," at www.awea.org, accessed March 15, 2006.

6 National Commission on Energy Policy, *Ending the Energy Stalemate*, Washington, DC, 2005

7 For an overview on State activity, see Thomas Petersik, "State Renewable Energy Requirements and Goals: Status Through 2003," Energy Information Administration, available online at http://www.eia.doe.gov/oiaf/analysispaper/rps/index.html.

8 Adjusted annually for inflation, the Renewable Energy Production Credit (REPC) provides a tax credit of 1.5 cents/kWh for wind, closed-loop biomass and geothermal. The adjusted credit amount for projects in 2005 is 1.9 cents/kWh. Electricity from open-loop biomass, small irrigation hydroelectric, landfill gas, municipal solid waste resources, and hydropower receives half that rate which is currently 0.9 cents/kWh. *Database of State Incentives for Renewable Energy*, www.dsireusa.org accessed on February 14, 2006.

**Figure 6: Industrial Energy Consumption, 2003**




*Source:* EIA, 2005

making demand in these sectors highly price inelastic. Industry also uses *natural gas* both as feedstock and for its heating value.

In contrast to oil prices, however, natural gas prices tend to be more regionalized rather than global. Thus, as prices rise in the United States, natural gas-intensive industries such as primary metals and fertilizer manufacturing are at a competitive disadvantage. Consumers have seen the result of this disadvantage in the closing of plants and the loss of a significant number of jobs to areas in which the price of natural gas is lower.

Neither coal nor renewable energy resources represent a significant source of energy for this sector. *Coal* represents just four percent of total industrial consumption while renewable sources contribute an additional three percent. Because of a reduction in demand in the steel industry and essentially flat demand for coal as a boiler fuel, the use of coal in the industrial sector has been in decline over the past few years. *Hydroelectric power and biomass* are the major renewable energy resources for this sector.

## Fuel Consumption in the Residential and Commercial Sectors

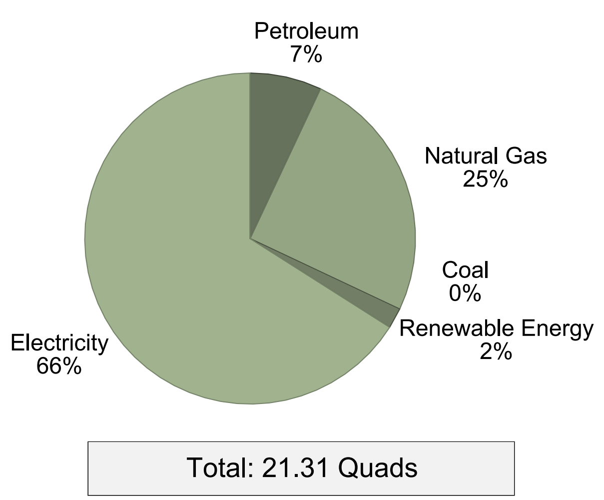
The largest use of energy by the residential and commercial sectors is for heating and cooling. Residential energy consumption totals 30 percent of stationary consumption, while the commercial sector accounts for 25 percent.

As Figures 7 and 8 demonstrate, the vast majority of energy consumption in both sectors is from the *generation of electricity*. Of the remaining energy consumed – which is primarily used for heating purposes – the majority comes from *natural gas and oil*. One-quarter of all residential fuel consumption comes from natural gas (5.33 quadrillion BTUs), while commercial consumption relies on natural gas to provide 18 percent of its needs (3.14 quadrillion BTUs). Petroleum (in the form of heating oil) provides a relatively small portion of residential and commercial consumption requirements. However, use of home heating oil is localized, thus representing a more significant portion of the energy consumed in specific regions of the U.S., such as the Northeast. Heating oil, primarily diesel, is used in small – albeit critical – quantities to provide backup power for hospitals, industry, apartments, and commercial buildings.

## Impacts of Efficiency and Conservation on Energy Demand Growth

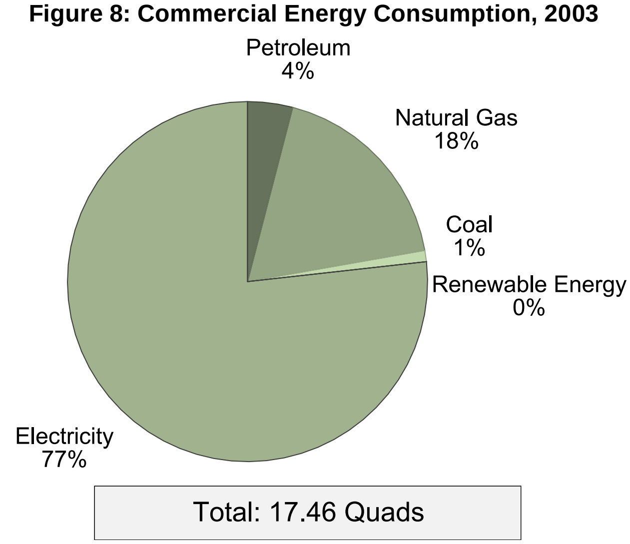
Energy efficiency and conservation have significantly reduced the growth rate of energy consumption in the United States over the past few decades. According to the National Energy Policy Development Group – the task force convened by Vice President Richard Cheney in 2001 to evaluate the nation's

**Figure 7: Residential Energy Consumption, 2003**




*Source:* EIA, 2005

**Figure 8: Commercial Energy Consumption, 2003**




*Source:* EIA, 2005

energy options – if energy intensity (measured by BTUs per unit of Gross Domestic Product (GDP) had remained constant since 1972, cumulative consumption in all sectors of the economy would have been about 74 percent higher through 1999 than it actually was, or about 70 quadrillion more BTUs.[9] This experience is consistent with trends on the international level. The economies of the member states of the Organization for Economic Cooperation and Development (OECD), whose members, like the U.S., have advanced industrial economies, use about 45 percent less energy today than they did in 1973 to generate each unit of GDP. Although these net savings include both improvements in energy efficiency and structural changes in the economy, this decrease has been driven by improved energy efficiency in key end-uses and by consumer behavior.[10]

Figure 9 further illustrates efficiency effects in the stationary energy sector. Energy intensity in 2003 is less than half of what it was in 1949. Had energy intensity remained at 1949 levels, cumulative energy consumption through 2003 would have been nearly 1,300 quadrillion BTUs higher.

Prior to 1970, energy prices in the United States in general were in decline. GDP and energy consumption both increased in a roughly symbiotic relationship. The oil shocks in the early 1970s, however, acted as a catalyst for the nation to conserve energy and become more energy efficient; in turn the tight relationship between GDP and energy use began to change. Growth in GDP outpaced the growth in energy use, meaning reduced energy intensities[11] throughout the economy. Some of this effect can be explained by energy efficiency initiatives, such as the adoption of energy efficiency standards for appliances with the subsequent introduction of energy-efficient appliances, and increased efficiencies of building shells. Structural changes to the economy, including a shift away from energy-intensive industries like primary metals and the growth of the service sector, also contributed to lower overall energy intensity.[12]

Even though energy intensity has declined dramatically, it is clear from the stationary energy consumption line in Figure 9 that it has not been sufficient to fully offset increases in demand. Several counter-trends to the decline in energy intensity are at work here, including the increased use of electronic equipment in the commercial and residential sectors (such as computers, copiers, and home entertainment systems), increased total building stock, larger homes, and a shift toward using electric motors for manufacturing purposes in the industrial sector.[13]

## 2.2 Future Energy Demand Projections

The CECA Forum determined that developing a 2025 projection of domestic energy use was an important tool for evaluating fuel use trends and keeping a long-range focus on energy. In this section, the assumptions used for generating the CECA 2025 projections are presented.

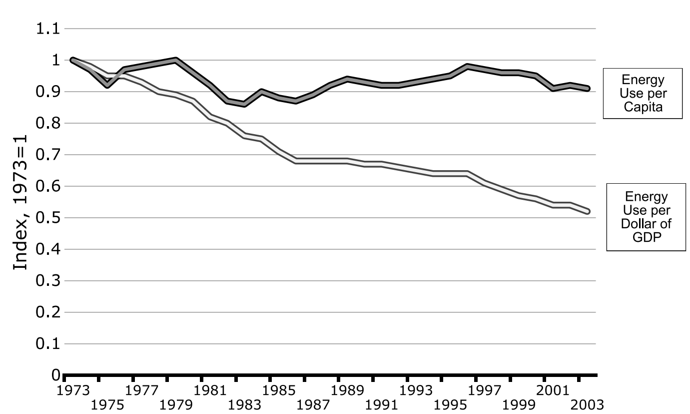
Projections of future energy demand generally start with a scenario which entails a continuation of current practices. This scenario is often called the "Business-as-Usual" scenario and provides a basis for comparing the impact of changes in energy practices.

### *Business-as-Usual Scenario*

The Business-as-Usual scenario or base case presented here is built from an analysis of four major international studies: the EIA's Annual Energy Outlook (AEO), IEA's World Energy Outlook (WEO), the EU's World Energy Technology Outlook (WETO), and the Institute for Energy and Economics, Japan (IEEJ's) Asia/World Energy Outlook (A/WEO).[14]

The first step in the CECA Forum's analysis was to determine a reasonable projection for economic growth for the United States, recognizing that energy use and economic development are intricately linked. The CECA projections used an economic growth rate of 3.1 percent in the U.S., which is consistent with the Energy Information

**Figure 9: Energy Intensity**




*Source:* EIA, 2005

9 Report of the National Energy Policy Development Group, *Reliable, Affordable, and Environmentally Sound Energy for America's Future*, Washington, DC, May 2001.

10 International Energy Agency, *World Economic Outlook*, Paris, France, 2004.

11 Energy intensity refers to the ratio of energy consumed to produce goods and services. Lower energy intensity indicates a higher level of energy efficiency.

12 Stephanie J. Battles and Eugene M. Burns, "United States Energy Usage and Efficiency: Measuring Changes Over Time," 17th Congress of the World Energy Council, Houston, Texas 1998.

13 *Ibid.*

14 A thorough discussion of these studies' projections as well as an explanation of how CECA analyzed them can be found in CECA, *Projecting Energy Needs for the Stationary Use Section: An Analysis of the Projected Energy Demands in 2025*, Washington, DC, November 2005.

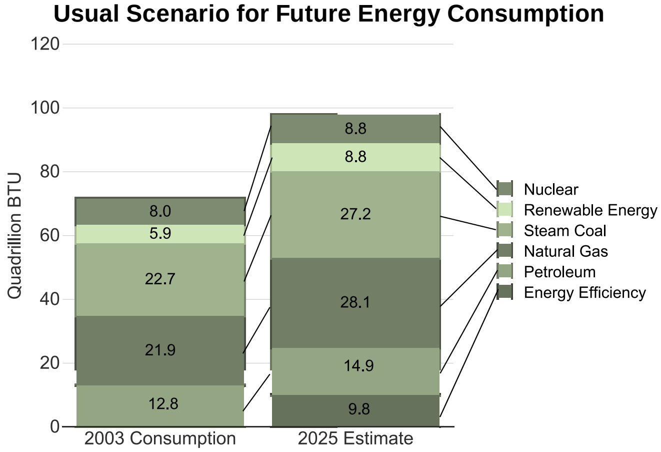
Administration's forecast estimate, as well as the growth rates assumed by the other major studies.[15]

As mentioned above, current energy consumption is estimated at approximately 71 quadrillion BTUs.

In order to project the estimated consumption of energy in 2025, CECA adopted the AEO's 2005 Technology Side Case forecast of approximately 98 quadrillion BTUs. The reason for selecting this number was that unlike the AEO's 2005 reference case, which assumes energy efficiency improvements, the AEO's 2005 Technology Side Case assumes that no additional energy efficiency enhancements will be made over the forecast period. This provided a clearer basis from which to evaluate the contribution of energy efficiency over the forecast period. The 2005 Technology Side Case suggested an increase in consumption of about 27 quadrillion BTUs, or roughly 38 percent. In evaluating future demand, CECA determined that energy efficiency will play a larger role than projected by the EIA study. If this is true, then energy efficiency will reduce the consumption of fossil fuels in roughly equal measure, but would not have much impact on nuclear energy because nuclear power is among the least expensive baseload power sources and is dispatched first. Renewable energy resources, on the other hand, would continue to experience significant growth due in part to favorable State and Federal policies. Figure 10 shows CECA's projections for each fuel group by the year 2025.

***Coal*** – Although CECA's projections anticipated that the amount of energy consumption derived from coal will rise by 20 percent, the overall rate of growth is lower than that of most other studies. Due to CECA's relatively aggressive estimates of economically-achievable energy efficiency potential, which lowers overall consumption, coal is predicted to represent in 2025 approximately the same share as today of stationary consumption (about 28 quadrillion BTUs). The market share for coal remains in line with projections by both the AEO and WEO, despite its lower growth rate projected by CECA. The A/WEO and WETO project the consumption of coal to increase more rapidly (48 percent and 42 percent, respectively). In the A/WEO projection, this is ostensibly the consequence of reduced availability for natural gas; in the WETO forecast coal appears to compensate for the contraction in the demand for petroleum. As noted previously, CECA foresees a continued strong role for petroleum in home heating that is incompatible with this view.

**Figure 10: Current and Estimated Business-as-Usual Scenario for Future Energy Consumption**




*Source:* CECA, EIA, 2005

***Natural Gas*** – Environmental concerns, coupled with the technological maturity of natural gas electricity generation technology, are projected to result in natural gas providing 29 percent (28 quadrillion BTUs) of the 2025 fuel mix.[16] Access to an adequate mix of resources from Alaska, liquefied natural gas (LNG), and other sources will be necessary to ameliorate the effects of the associated 29 percent increase in consumption from current levels. CECA's projection of a 32 percent share of the fuel mix is in line with that of the other major studies; however, CECA anticipates lower growth rates from current consumption levels than do the other studies. This differentiation in projections is due to the more robust projections of energy efficiency assumed by CECA. The WETO study, which projects an increase of 38 percent, presumably offsets forecasted reductions in petroleum with stronger increases in natural gas use. CECA anticipates that the A/WEO projection of a 14 percent increase in the consumption of natural gas may underestimate the availability of new resources to satisfy growth in demand driven by a more robust pace of economic activity.

***Petroleum*** – The CECA Forum's 2025 projection assumed the share of petroleum in the energy mix to be approximately 15 quadrillion BTUs, or 15 percent of 2025 fuel demand.[17] This estimate is in line with the EIA and WEO projections of petroleum's share of the mix.[18] This corresponds to a rise in petroleum consumption of about 17 percent. The projection does not foresee the viability of the far more modest five percent gain in petroleum consumption forecast by A/WEO, whose forecast of GDP is lower. Likewise, the WETO's projected decline of 15 percent in oil consumption

15 Global growth projections tend to hover around 3.1percent. The WETO, the AEO, and the WEO all project global growth at around 3.1 percent or 3.2 percent, driven largely by growth in emerging markets in Asia. The A/WEO is the outlier at 2.7 percent. The figures for the U.S. GDP growth vary more substantially. The AEO's assumption of 3.1percent over the entire forecast period is the most robust; the WEO assumes 2.3 percent and the WETO assumes growth of around 2.0 percent. CECA's view is that the pace of world GDP growth and the concomitant energy price fluctuations will be an important driver of energy consumption decisions. As a result, CECA elected to adopt the 3.1 percent growth figure.

16 If efficiency's contribution to total energy forecast were deducted from total forecasted demand, the share of natural gas would be 31 percent, or the same as the baseline case.

17 If efficiency's contribution were deducted from total forecasted energy demand, the share of petroleum would be 17 percent, similar to the baseline case.

18 The AEO forecasts petroleum to constitute 17 percent of the mix and the WEO projects 16 percent.

seems improbable, considering the growth projections and the Northeast's continued reliance on home heating oil.

***Nuclear Energy*** – Higher prices for energy, concerns over carbon emissions, and increasing competition for fossil fuels led to CECA's projection of an increase in nuclear energy capacity required in 2025. For this reason, CECA forecasted nuclear energy's capacity to expand by approximately 10 percent from 2003 levels to account for slightly less than nine percent (nine quadrillion BTUs) of the overall 2025 fuel mix.[19] This increase is driven by continued operational improvements that boost the capacity of nuclear power plants, coupled with planned additions within the forecast period. CECA's analysis indicates that nuclear energy has strong potential to play a major role within the study period and an even more significant role after 2025 as plant siting, design, and licensing processes are completed for construction of a substantial fleet of new plants. This estimate is consistent with that of the EIA, the MIT Nuclear Study,[20] and the WEO.

***Renewable Energy Resources*** – Renewable energy resources are projected to grow by 49 percent (approximately nine quadrillion BTUs) through 2025. As a result, they will constitute about nine percent of the overall stationary energy mix in 2025.[21] This is higher than the EIA's estimate of renewable energy resources rising by 37 percent to constitute nine percent of the 2025 energy mix. The reason is that Renewable Portfolio Standards currently in place at the State level, once fulfilled, will together contribute about 7.4 percent of total generation in 2025. An additional 2.2 percent of 2025 consumption, according to the EIA, will come from hydroelectric sources in States that have no RPS.[22] The WEO also projects renewable energy resources to constitute about 10 percent of the 2025 energy mix.

***Energy Efficiency*** – The CECA Forum's projections estimate that 10 percent or 9.8 quadrillion BTUs of 2025 demand will be filled by energy efficiency. This is higher than the EIA's reference case estimate, which appears to include about five percent of total energy demand. It is lower than would be inferred by implementation of improvements identified in an analysis conducted by the American Council for an Energy Efficient Economy (ACEEE),[23] which was based on a comparison of 11 leading energy efficiency studies and which estimates a median electricity sector achievable potential of approximately 24 percent. The estimate of 10 percent reflects concern that the EIA's forecast underestimates the amount of energy efficiency readily accessible in the commercial, residential, and industrial sectors. The CECA projection assumed that the numbers from the ACEEE study are more indicative of economically attainable energy efficiency, but that additional policy incentives are likely to be required to attain the 24 percent level based on the data presented in the ACEEE's analysis. The result of this more robust energy efficiency projection is a lower level of consumption growth for all fuels than that projected by the four major international studies.

## Effects of Greenhouse Gas Reduction Legislation on Projections

### *Background on Legislation*

The U.S. currently has no Federal laws directly regulating emissions of carbon dioxide and other greenhouse gases. A growing number of climate change bills has been introduced in each Congress since 1999, with the first Congressional bill to actually cap GHG emissions being introduced in 2003. Certain States and Regions are taking aggressive positions and promulgating polices to restrict carbon emissions from a State and Regional standpoint. The trend is increasing attention on the need to reduce greenhouse gas emissions and providing added momentum for lawmakers to enact GHG legislation.

If Federal carbon constraint legislation (known as climate change legislation) were to be enacted, it would have profound effects on the nation's energy economy and energy consumers. An informed understanding of the 2025 energy mix must therefore take into account the impacts of potential laws addressing climate change.

19 If efficiency's contribution to total energy forecast were deducted from total forecasted demand, the share of nuclear energy would be about 10 percent.

20 MIT, *The Future of Nuclear Power*, Report of the MIT Nuclear Energy Study, Cambridge, MA, 2003.

21 If efficiency's contribution to total energy forecast were deducted from total forecasted demand, the share of renewable energy would be about 10 percent.

22 The 2.2 percent figure does not include hydroelectric resources in States that have an RPS. Since some hydroelectric resources are not eligible to fulfill RPS requirements in certain States, the 2.2 percent represents a conservative estimate.

23 Steven Nadel, Ann Shipley and R. Neal Elliott, "The Technical, Economic and Achievable Potential for Energy-Efficiency in the U.S. – A Meta-Analysis of Recent Studies," from the proceedings of the 2004 ACEEE Summer Study on Energy Efficiency in Buildings. ACEEE examined 11 different studies including ones examining the U.S. as a whole (Interlaboratory Working Group 2000) and studies on California (Xenergy 2002 and 2003), Massachusetts (RLW Analytics and Shel Feldman Management Consulting 2001), New York (Optimal Energy et al. 2003), Oregon (Ecotope 2003a and 2003b), Southwestern States (SWEEP 2002), Utah (GDS 2004), Vermont (Optimal Energy 2003), and portions of Washington State (Puget Power 2003).

While there is currently no mandatory national policy on greenhouse gas emissions,[24] many government agencies, both in the U.S. and internationally, as well as companies in the private sector, are taking actions to reduce emissions. In the States, a coalition of Northeastern States is designing a carbon emissions cap-and-trade scheme to reduce the Region's electric sector GHG emissions (known as the Regional Greenhouse Gas Initiative (RGGI)), while other States are instituting GHG reduction strategies of their own. In the private sector, several companies, including BP, Shell, DuPont, and General Electric, have taken significant steps to curb their GHG emissions, and the Chicago Climate Exchange is a voluntary GHG market in North America.

Should national GHG legislation be enacted, the most widely discussed approach to addressing the issue involves some form of an emissions cap supplemented by a trading regime.25 Under such a system, greenhouse gas emitters would match the amount of greenhouse gas they generate with greenhouse gas allowances. Entities with excess allowances can then sell them in the trading market to others with insufficient allowances. This allows each entity to evaluate the cost of greenhouse gas emissions control against the value of the allowances, creating a market-driven approach to greenhouse gas emissions control. Such a program now exists to control $SO_2$ emissions under the Clean Air Act Amendments of 1990 and has generally been viewed as a successful, cost-effective means of reducing emissions.

## *Potential Legislative Provisions: McCain/ Lieberman Legislation as an Example*

While cap-and-trade systems are simple in concept, they can be equipped with numerous features that dramatically affect the cost and performance of the policy. The Climate Stewardship Act of 2003, Senate Bill 139 (S. 139), introduced by Senators John McCain (R-AZ) and Joe Lieberman (D-CT), provides one example of the form such a policy might take. While it failed by a vote of 43 to 55 on the Senate floor in October 2003, it attracted substantial attention and was the subject of several modeling efforts that provide insight into how a cap-and-trade system could affect energy consumption decisions. The CECA Forum examined S. 139 and its impact on fuel use only because this legislation was the subject of the most extensive analysis. Subsequent carbon management plans have been proposed and the impacts may differ, but the analyses of S. 139 give insights into how similar climate legislation might influence the projections of fuel requirements. The analyses of S. 139 were performed by the Energy Information Administration,[26] Charles River Associates,[27] and the Massachusetts Institute of Technology's Joint Program on the Science and Policy of Global Change.[28]

As drafted at the time, the provisions of the McCain/ Lieberman bill would come into effect in two phases. Phase I, from 2010 through 2015, would lower the emissions of GHG's among covered entities[29] to 2000 levels. Phase II, starting in 2016, would bring emissions down to 1990 levels, presumably in perpetuity or until Congress acted on a possible Phase III plan. Distribution of allowances would take place using a complex system in which allowances are either grandfathered (i.e., provided for free) to existing entities or sold at auctions.[30] Allowances from systems outside the United States may be used to meet up 10 percent of obligations in Phase I and 15 percent in Phase II. Under special circumstances entities may borrow allowances[31] and excess allowances may also be "banked," or used in future compliance periods. This practice is encouraged in Phase I to help "pay" for Phase II.

Although the three analyses of S. 139 provide different assessments of future energy consumption,[32] the overall picture is largely consistent – coal consumption generally declines, while gas and oil rise, but by less than under the Business-as-Usual Scenario. Increases in consumption of energy services are sustained by increases in production of renewable technologies and nuclear energy. Energy efficiency occupies an important role as well; however, the studies do not model energy efficiency as a discrete resource and so it is difficult to ascertain its role in meeting demand under this type of legislation. This is a potentially serious shortcoming in all three models. By contrast, modeling performed for the RGGI process showed that explicit treatment of energy efficiency in the models resulted in significantly lower cost projections for the RGGI cap-and-trade rule when energy

24 While the U.S. Congress has not acted on climate change legislation as of publication of this report, prominent Members of the U.S. Senate, including Sen. Pete Domenici (R-NM), Chairman of the Senate Energy and Natural Resources Committee; Sen. Jeff Bingaman (D-NM), Ranking Member of the Committee; Sen. Tom Carper (D-DE); and Sen. John McCain (R-AZ), have all indicated that they intend to reintroduce new climate legislation either during the 109th Congress or in the 110th Congress. To set the stage for such legislation, Senators Domenici and Bingaman issued a white paper of design elements, entitled, "*Design Elements of a Mandatory Market-Based Greenhouse Gas Regulatory System*," in February 2006 and held a conference on the white paper in April 2006.

25 An alternative to conventional emissions cap and trade is one based on reducing the rate of GHG emissions, otherwise referred to as an efficiency based system, such as that developed by former EPA Deputy Administrator Alvin Alm and former Senator J. Bennett Johnston (D-LA).

26 Energy Information Administration, "Analysis of S. 139, the Climate Stewardship Act of 2003: Highlights and Summary," Office of Integrated Analysis and Forecasting, June 2003.

27 Anne E. Smith. et al. "The Full Costs of S. 139, With and Without Phase II Requirements," Charles River Associates, Washington, DC, April, 2004.

28 Patsev *et al.*, "Emissions Trading to Reduce Greenhouse Gas Emissions in the United States: The McCain Lieberman Proposal," MIT Joint Program on the Science and Policy of Global Change, June 2003, p. 8.

29 Households and agriculture are exempt from the law; the industrial, commercial, transportation sectors are all covered. Certain entities, such as petroleum refiners and importers, are responsible for indirect emissions.

30 In a compromise, the bill that went to the Senate floor only included Phase I provisions; Phase II of the original bill was left out.

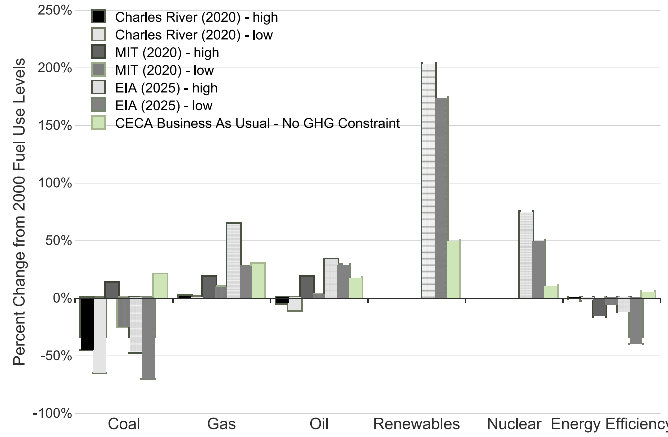
31 Charles River Associates does not anticipate this will be an economically attractive option.

32 These studies model changes to the overall energy economy, including the transportation sector, which relies heavily on oil.

efficiency investment was increased. Modeling exercises that take into account energy efficiency are valuable tools to provide more realistic assessments of future energy consumption and increased attention should be devoted to such modeling.

Such Federal legislation may have important effects on stationary energy applications, largely because reliance on fossil fuels in the electric power sector dictates that consumption of primary fuels will decrease as consumers respond to price increases. In fact, as Figure 11 demonstrates, stationary sector fuels exhibit the largest fluctuations in demand. This impacts two vital economic indicators, GDP and consumer costs.

**Figure 11: Changes in Fuel Consumption Levels Projected by S. 139 Analyses**




*Source:* Booz Allen Hamilton compilation of study data. Charles River and MIT report only fossil fuel consumption changes, not changes in renewable or nuclear consumption. Charles River estimates are for Phase I only. 2005

## Potential Impacts of Greenhouse Gas Reduction Legislation

***GDP Indicators*** – The analyses forecast a range in GDP decreases from 0.4 percent to 1.6 percent per year if the McCain/Lieberman legislation were to be enacted. These changes are driven in large part by the availability of outside carbon allowances; the higher figures assume that outside allowances, if available, would have a negligible impact on GHG allowance prices. Despite the costs of these changes, the EIA found that other factors, such as labor productivity, would likely play a more significant role in shaping the size of the U.S. economy in 2025 than would any of the consequences of S. 139. Moreover, since none of the three models addressed the positive economic impacts of efficiency measures, these GDP impacts may be overstated. The RGGI modeling process showed that the cap-and-trade rule produced small but positive changes in Gross Regional Product.

***Consumer Costs*** – Under S. 139, consumer costs rise but are offset by auction revenue receipts. According to EIA, revenues from the sale of emissions allowances sold at auction will be returned to consumers through the Climate Change Credit Corporation (CCCC), a not-for-profit entity created by the bill. The CCCC would redistribute the funds via appliance rebates, transition assistance, and other transfer payments. As a consequence, the bill's cost per household would be between $50 and $100 per year. Consumer costs would, however, be further mitigated if the models took into account direct customer energy bill reductions from efficiency investments, as well as the indirect effects of reduced demand, which reduces wholesale energy prices and thus reduces base energy costs. When this was done for the RGGI program, consumer energy bills were projected to decrease by $50-$100 annually—the opposite effect found by these three models.

***Impact on Fuels*** – Climate change legislation similar to S. 139 will have an uneven impact on fuel choices as certain fuels have high carbon content and therefore high GHG emissions, while others have none. A detailed discussion of each fuel under a greenhouse gas reduction legislative scenario follows:

***Coal*** – As the fuel with the greatest carbon content per unit of energy of all the fossil fuels, coal would experience the most significant reductions in consumption, dropping by as much as 70 percent compared to projected baseline levels (see Figure 11). Since coal is also the most inexpensive fuel on an energy content basis, it would be projected to experience the most significant price increases of any of the fuels. Price increases ranging between 87 percent and 435 percent are projected to occur in the analyses. The availability of outside emissions allowances has significant effects on coal consumption. Scenarios that assume few restrictions on allowances show a slight increase in coal consumption, whereas scenarios that assume more restrictions on allowances show a sharp decrease in the use of coal.[33]

Technology, however, can play an important role in mitigating this impact on coal. In an analysis of the effect of carbon legislation similar to that of S. 139 that included regulation of SOx, NOx, and mercury, CECA found that the role for coal may actually be more robust. IGCC plants would constitute about 15 percent of all new capacity additions through 2025. Deployment of IGCC plants would result in a modest increase in coal consumption from current levels. Indeed, should prices for natural gas increase markedly, incentives for IGCC and carbon sequestration technologies associated with coal burning could bring coal production upward.

33 The increase registered in the MIT study is yielded if Phase II is not included and credits are applied as economic.

The most significant impact of S. 139 on coal consumption with respect to consumer interests is that coal consumption will decrease at a greater rate than will overall electricity consumption. As a primary consequence, greater fuel diversity will be required to offset the strong impacts of the decreasing use of coal resulting from the escalating cost of electricity from coal.

***Natural Gas*** – Natural gas combustion yields much more energy per unit of carbon released than coal and, as a consequence, the studies forecast that use of natural gas would stay steady or increase. The Charles River and MIT studies project slight gains in the use of natural gas, but the EIA forecasts that the increase could amount to as much as 64 percent (see Figure 11). As with coal, rules regarding utilization of external emissions credits would significantly impact the shape of the 2025 natural gas market, although to a lesser extent. Natural gas utilization would be about five percent higher under a less restrictive credit scenario than if all allowances had to be sourced domestically.

Assumptions about availability of future natural gas supplies are essential to the natural gas forecasts. Higher prices for natural gas stemming from supply constraints would focus significant attention on additional natural gas resources, making investments in pipelines, LNG facilities, and hitherto untapped deposits increasingly economic. It could also increase political pressure to open areas presently closed to gas extraction, as well as to overcome objections to siting new LNG and other facilities. Part of the supply solution would also involve increased reliance on foreign sources, further exacerbating U.S. energy dependence and the balance of trade deficit. On the demand side, accelerated roll-out of high-efficiency turbines, including combined heat and power and other gas-fired distributed generation technologies, would maintain levels of energy service consumption while cutting fuel consumption.

***Petroleum*** – The studies do not agree on how oil consumption will change during the time period of the CECA study. Charles River Associates forecasts a decline of up to 11 percent from current levels while MIT and EIA both project increases as high as 18 percent and 33 percent, respectively. Comparing the three study forecasts with CECA's Business-as-Usual Scenario is imprecise. CECA's forecast only addresses increases in the stationary sector, while the three studies include transportation. As such, distinguishing the studies' assessments of changes in the transportation sector patterns from those that will take place in the stationary sector is difficult.

Despite this imprecision in assessments, certain conclusions can be drawn. As noted previously, petroleum use in the stationary sector is limited to home heating and certain industrial applications. It is not likely that petroleum use in industrial applications would change demand significantly with respect to the Business-as-Usual Scenario because of a lack of substitute fuels for their processes. Use of home heating oil, by contrast, may be reduced under a legislatively mandated greenhouse gas reduction scenario in favor of greater natural gas usage and increased energy efficiency. Ascribing the bulk of the changes cited by the studies to transportation, leaving stationary sector consumption unchanged, therefore seems to be a reasonable conclusion.

***Nuclear Energy*** – The MIT and Charles River Associates analyses do not forecast the effect of S. 139 on nuclear energy or renewable energy resources. Only EIA was comprehensive in dealing with all fuels. In the EIA analysis, nuclear energy would play a major role in meeting future energy requirements, with growth forecasted to increase between 50 and 75 percent above current levels by 2025, and investments expected as early as 2012. In the EIA's modeling effort, the higher growth rate in use of nuclear energy is a function of high natural gas prices that make nuclear energy more competitive. By contrast, the EIA finds that nuclear energy grows more slowly in a scenario based on accelerated technological progression among other energy technologies.

The need for increased reliance on nuclear energy would force a more focused debate on a range of issues associated with it. While the next several plants built in the United States would most likely be constructed on existing nuclear plant sites, siting nuclear power plants will likely remain a challenge in the longer-term future. That said, the challenge may be resolved as energy prices rise and concerns over greenhouse gas emissions cause a reassessment of nuclear energy as a zero-emissions resource. The issue of how to dispose of nuclear waste most safely and cost-effectively could grow, even if the Yucca Mountain geologic repository reaches completion sometime after 2010. The issue of used nuclear fuel reprocessing, commercially available abroad but not practiced in the United States, might also be revisited to address issues relating to proliferation. The Bush Administration's 2007 budget includes a new U.S. Department of Energy (DOE) program, the Global Nuclear Energy Partnership (GNEP), to study the potential of proliferation-resistant, advanced technology spent fuel recycling in the United States. The new recycling program is funded at $250 million for 2007.[34]

***Renewable Energy Resources*** – In the EIA's study, renewable energy resources undergo the most significant expansion of all energy technologies, with increases of up to 200 percent forecasted. This would boost renewable energy resources' share of the fuel mix from about eight percent to almost 20 percent, placing renewable technologies second only to natural gas. Biomass and wind power account for most of

34 Budget of the United States Government, OPM, Fiscal Year 2007.

these gains, though solar power technologies rise as well. Use of hydroelectric power would also likely increase through capacity additions and efficiency upgrades at existing hydroelectric facilities, conversion of non-hydroelectric dams, and the development of the small hydropower potential.

Increased reliance on renewable energy technologies generates a range of concerns as well. Although wind power is cost competitive or nearly cost competitive with other fuels in certain regions, and wind power developments can have relatively short lead times, wind power capacity will continue to be limited in key areas by discord on appropriate use of sites that are optimal for wind generation. Although the role of solar power is likely to remain small for some time because of technological limitations and costs, areas with relatively high concentrations of solar energy may have to develop means of managing increasingly complex power flows because of solar power's intermittent nature. The intermittency of wind and solar power may require policy responses to ensure adequate resource availability.

The consequences of an increase in biomass depend largely upon the extent to which biomass can grow as a stationary resource. At present the most promising growth prospects for biomass are for use as a transportation fuel via ethanol production. While biodiesel can displace petroleum diesel in peaking diesel generators, the fact is that biomass liquid fuels will most likely not play as significant a role in the stationary sector as they will in the transportation sector. Biomass energy production based on agricultural and animal wastes is limited by these resources' low energy density, making them best suited to niche distributed generation applications as opposed to large-scale energy production.

***Energy Efficiency*** – S. 139 anticipated a strong role for energy efficiency, as evidenced by the legislation's provision for the Climate Change Credit Corporation to return to consumers revenues generated during emissions allowances auctions. These transfers would take the form, in part, of rebates for energy efficiency enhancements; S. 139 explicitly indicated that a primary aim of that legislation was to make energy efficient appliances available to consumers. Unfortunately, none of the three studies assess the amount of energy efficiency that will be stimulated as a result of both the CCCC's incentives as well as those associated with higher energy prices. This failure to model properly the direct and indirect economic benefits of energy efficiency investments is a serious limitation of these three modeling approaches. Other approaches, such as those used in the RGGI process, have shown much more positive economic impacts when the effects of efficiency are better characterized. These divergent findings suggest that more work is needed to improve the accuracy and thoroughness of climate change modeling before the projected costs of climate change policy are deemed credible.

As noted earlier, CECA's analysis of the ACEEE\ meta-study of various energy efficiency assessments points toward a median national energy efficiency potential of about 24 percent in the electricity sector. In the context of higher energy prices and a strong incentives regime, this may serve as a reasonable upper bound for true energy efficiency potential.

## *Other Key Variables Influencing Projections*

With the exception of a legislated greenhouse gas reduction scenario, the Business-as-Usual Scenario does not assume that any policy changes would be enacted. This section identifies several policies, market, and geopolitical issues which will likely act to shape 2025 energy demand, and thus impact the projections discussed in the previous sections.

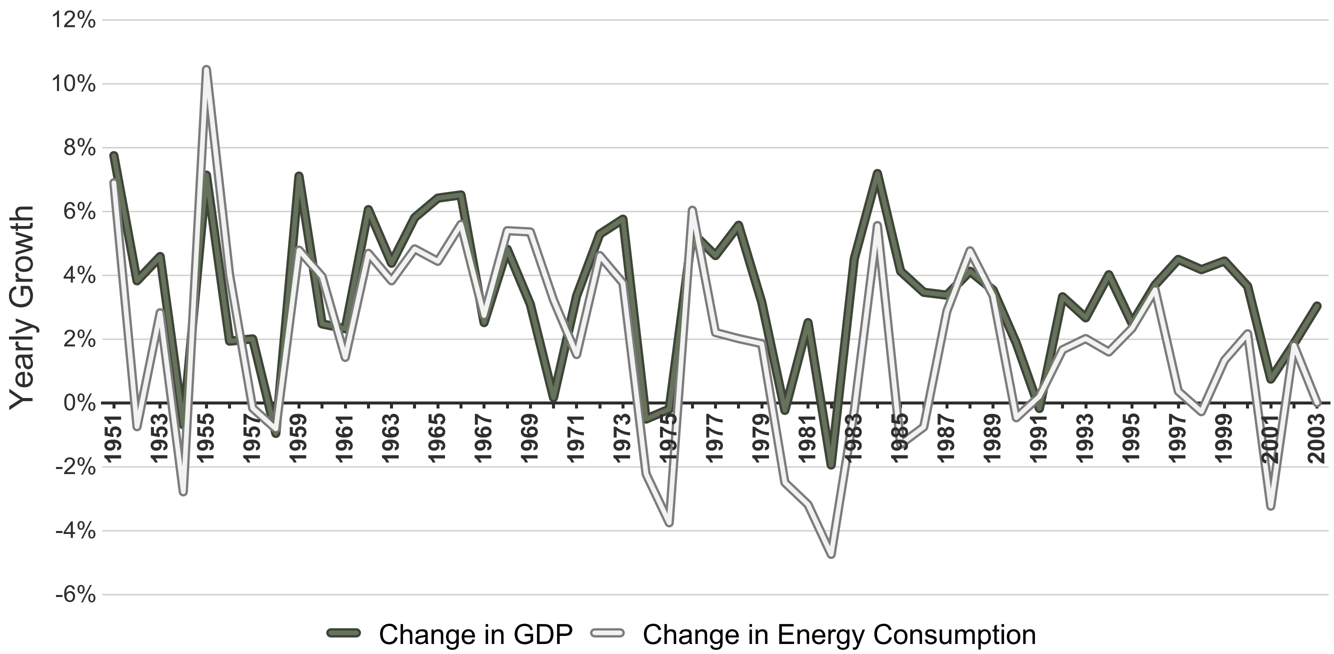
***GDP Scenarios*** – Energy demand and changes in GDP are highly interdependent: Figure 12 demonstrates this relationship. The economic downturn in 2001, stimulated by corrections in the financial markets following over-investment in the technology sector, resulted in a precipitous decline in the use of fuels in the stationary sector. Similarly, the economic malaise driven by reverberations from the default on debts throughout Latin America in 1982 and the 1979 oil shock helped to drive the single largest contraction in energy consumption in more than half a century. By contrast, the long period of economic expansion in the 1960s was accompanied by a sustained period of strong growth in consumption.

Although the United States currently is in a period of modest economic expansion, numerous macroeconomic variables, including the current account deficit, high levels of government and household debt, inflation, and potential instability in the housing market, contribute to uncertainty about the direction of the economy over the 20 year period of the CECA study.

A key point, as noted above, is that the relationship between energy and economic growth continues to evolve. Advances in technology and shifts in the structure of the economy that de-emphasize energy-intensive industries in favor of a more knowledge-driven service economy reduce changes in future use of energy as the economy grows. Indeed, the fact that the economy of the United States has continued to grow in spite of relatively high energy prices is testament to this decoupling.

***Fuel Prices and International Markets*** – Oil has long been bought and sold in an integrated market: prices fluctuate as supply and demand work to clear the marketplace. A global infrastructure of tankers and pipelines transports oil to

**Figure 12: Changes in GDP and US Stationary Sector Energy Consumption**




*Source:* EIA, U.S. Bureau of Economic Analysis, *2005*

locations in which it can fetch the highest price, so prices do not differ substantially from region to region. Coal and natural gas, however, have been driven by different factors until very recently. Because of their abundance, extraction and transportation costs were the primary drivers of price. For this reason, technological and process improvements that would translate to decreases in the cost of extracting and distributing these commodities were anticipated in the 1990s to drive prices consistently lower.

This has begun to change with the dramatic increases in energy consumption in the developing world, primarily China, India, and other countries in Asia. Experts broadly agree that Asia is likely to be the locus of future demand for energy. As growth in Asia eclipses the region's ability to procure adequate supplies from traditional repositories, competition for these fuels has become more intense and more global. As a result, reserves in areas from Kazakhstan to Venezuela now figure into the plans of energy strategists from across the globe. Outlays for infrastructure—notably, LNG facilities, pipelines, and other transportation infrastructure—will create a market that behaves similarly to oil markets.

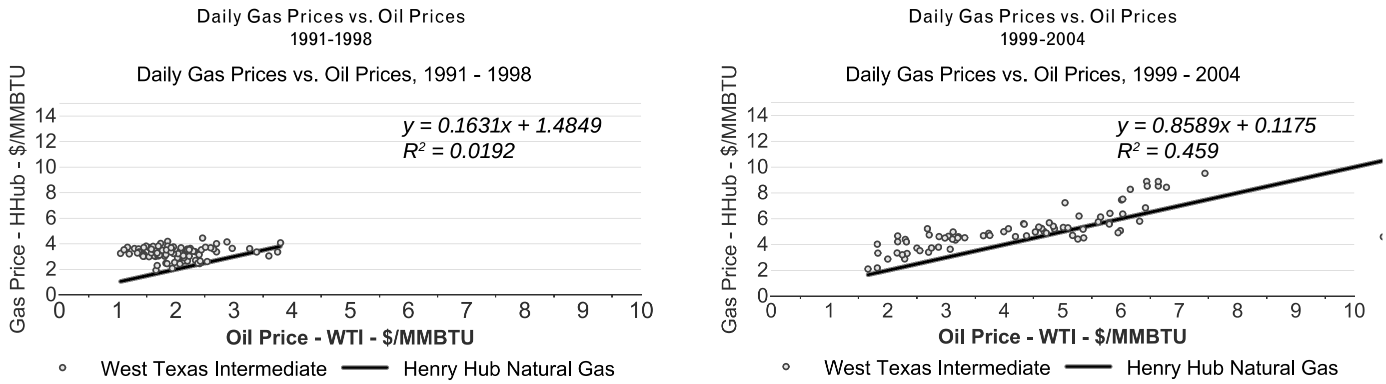
The increases in consumption manifest themselves in the marketplace, which transforms the way in which prices are determined. Figure 13 demonstrates that while the correlation between oil and gas prices between 1991 and 1998 was not particularly noticeable, the correlation strengthened in the period from 1999–2004. During the former period, the demand for natural gas was easily satisfied by available supply. A plausible explanation for this was that from 1999-2004 a tighter balance between supply and demand defined the market than it did from 1991-1998. As a consequence, the price for natural gas was determined less by production costs and more by the play of supply and demand in the markets.[35] In this respect, natural gas is following an evolution similar to that of oil decades ago.

The impact of these changes is highly uncertain. Although their economic growth has been impressive, developing countries' economies also tend to be the most volatile. The scorching pace of investment in China has raised concern among some economists that China's economy is overheated while India's growth sits in the shadow of a large public debt and a rigid social safety net. The success or failure of these economies and the associated swings in demand over the coming decades will have strong impacts on choices regarding the consumption of energy in the United States.

***Fuel Prices and U.S. Public Policy*** – Public policies will influence dynamics in price and the role of competition in energy markets will be particularly influential. Restructuring of the electric power industry in the 1990s stimulated a boom in construction of gas-fired generation. In addition, the result of California's deregulated market—and the ensuing controversies regarding electric power restructuring—

35 Since 1980, CECA has produced a series of trend line analyses projecting that, as a result of deregulation of oil and natural gas, prices for oil and gas would track one another over time. CECA's projections proved true. See, Consumer Energy Council of America, Washington, DC, *Smart Choices for Consumers: Analysis of the Best Ways to Reduce High Heating Costs*, November 2005; *Oil, Gas, or ...?. An Evaluation of the Economics of Fuel Switching Versus Home Energy Conservation*, March 2001; *Oil, Gas, or ...?. Technical Support Document for a Consumer Decision Making Guide on Fuel Switching and Home Energy Conservation*, January 1994; *Technical Support Document for a Consumer Decision Making Guide on Fuel Switching and Home Energy Conservation*, August 1991; *Technical Support Document for a Consumer Decision Making Guide on Fuel Switching*, May 1989. *An Analysis of the Economics of Fuel Switching Versus Conservation for the Residential Heating Oil Consumer*, October 1980.

**Figure 13: Correlation between Natural Gas and Oil Prices (1991-1998 and 1999-2004)**




*Note: Two outliers removed from gas price (2/23/04, $11.10/MMBTU & 12/29/00 $10.50/MMBTU)*
*Source:* Bloomberg data, Booz Allen Hamilton analysis

demonstrated the deep relationship between market rules and prices. Indeed, a report by the Consumer Federation of America asserts that natural gas prices lack market transparency and "manipulation and abusive practices have been a part of these markets since 2000."[36]

***Fuel Prices and Fuel Supply*** – Significant changes in the supplies of fossil energy also could shift the consumption of energy dramatically as additional supply can result in a slowing of price increases and, in turn, an increase in consumption. Principal among these is access to natural gas, which may gain importance through one of several channels:

- Access to the natural gas deposits of Alaska's North Slope via a pipeline to the lower 48 States. According to the National Commission on Energy Policy, Alaska's North Slope holds about 20 percent of all reserves, and the total resource base there may approach 300 trillion cubic feet (tcf), equivalent to a supply of about 15 years at 2003 levels of consumption.[37] Currently, uncertainty surrounding the return on investment for such a pipeline limits investor appetite in the project in the absence of public assistance.

- Access to resources in the Rocky Mountains and other areas. The National Petroleum Council estimates that the Rocky Mountains hold an additional 284 tcf, with a strong likelihood for large undiscovered potential resources.[38] Exploitation of this and other resources, however, elicits controversy over the impact of drilling in sensitive ecological environments.

- Increased use of LNG. Vast resources of natural gas exist outside the United States. Unlike oil, however, natural gas is difficult to handle by virtue of its low density and volatility. Shipments of natural gas totaled about two percent of national consumption in 2003[39] but constructing additional LNG terminals could increase this number. Some studies, such as the report of the National Commission on Energy Policy, believe that LNG does not appear to pose a greater safety hazard to society than other widely used sources of energy.[40] Persistent perceptions among the public of safety risks associated with such facilities, however, can limit their more widespread use at present.

- The availability of non-conventional sources of oil will depend on the extent to which rising prices of oil and improved technologies for exploring and extracting the petroleum render additional fields economically feasible for recovery. These may include tar sands deposits in Canada, oil shale deposits in Colorado and Utah, as well as deep-water reserves.

- Geopolitical disruptions could also potentially impact oil supply. The Arab Oil Embargo of 1973 and the Iranian Revolution of 1979 caused significant economic dislocation in the United States and resulted in a long period of improvements in energy efficiency and interest in alternative fuels. Saddam Hussein's invasion of Kuwait in 1990 helped to drive an oil price spike that contributed to the 1991 recession that reduced the level of energy consumption in the United States (see Figure 12). More recently, disruptions in Venezuela and West Africa have raised concerns about the reliability of supplies in those regions.

36 Mark Cooper, "Fueling Profit: Industry Consolidation, Excess Profits and Federal Neglect Domestic Causes of Recent Gasoline and Natural Gas Price Shocks." Consumer Federation of America, 2004, p. 4.

37 See National Commission on Energy Policy, *Ending the Energy Stalemate*, Washington, DC, 2005. http://www.energycommission.org/.

38 "Balancing Natural Gas Policy – Fueling the Demands of a Growing Economy," National Petroleum Council, 2003. See http://www.npc.org/.

39 United States Department of Energy, "U.S. Natural Gas Summary," Energy Information Administration, 2005.

40 National Commission on Energy Policy, "Ending the Energy Stalemate," Washington, DC, 2005.

***Progression of Technology*** – The pace of technological progression in certain industries will influence the stationary energy application mix by enhancing the cost-effectiveness of technologies presently too expensive to compete in the marketplace. The pace of progression is difficult to predict and is driven by, among other factors, the priorities of governmental research and development (R&D), changes in fuel prices, the regulatory environment, and the health of the investment climate. The impact of such progression can be dramatic. For example, if technology advancements can be achieved from the U.S. Department of Energy's Coal R&D Program, technologies like IGCC and sequestration would have a profound impact on the future of coal use in a carbon-constrained world. Additionally, in a study for DOE's National Energy Technology Laboratory, Booz Allen Hamilton calculates that IGCC plants could cost up to $200/kW less to install than traditional pulverized coal plants by 2025 due to technology improvements.[41] Such cost savings would diminish coal's negative environmental footprint, offset the potential volatility associated with natural gas, and provide low-cost power.

A range of other technologies also may experience technological breakthroughs that would enhance their value proposition. These include stationary fuel cells, photovoltaics, high-efficiency micro turbines, and biomass systems. Significant breakthroughs, for example, in nanotechnology associated with photovoltaics could reduce the price of solar power sufficiently to suggest a much greater role for this renewable energy resource. Converting coal to liquid fuels like diesel and gasoline is also gaining more attention due to high prices. Coal to liquid technologies could play a critical role in supplying transportation fuels in the future. Converting coal to gas as a substitute for natural gas is also gaining attention. Coal to gas technologies can play a critical role in meeting industrial demands.

## 2.3 Summary of CECA Fuel Projections Through 2025

The scenarios discussed in this chapter provide a synopsis of the variables that will influence fuel supply and technology in the 20 year timeframe of the CECA study. Reasonable projections of future energy needs will drive new public policies on fuel supply, fuel availability, fuel diversity, and technology advancement. The public policy implications for future fuel supply and technologies to meet stationary energy needs are discussed in Chapters Three and Four and set the stage for the conclusions and recommendations advanced by the CECA Forum in Chapter Five.

41 Booz Allen Hamilton, "Coal-Based Integrated Gasification Combined Cycle: Market Penetration Strategies and Recommendations," Washington, DC, August 2004. Paper produced for the DOE's National Energy Technology Laboratory and the Gasification Technologies Council, p. 24.

# CHAPTER THREE:

# Key Fuels and Technologies Policy Issues with CECA Forum Findings

## 3.0 Building for the Future: Key Fuels and Technologies Policy Issues

As seen in Chapter Two, a broad portfolio of fuels and technologies will be required to meet the nation's projected energy demands through 2025. New technology breakthroughs, potential climate change policy shifts, and changing economic priorities will affect the nature of the energy portfolio over the next 20 years. It is clear, however, that the major fuels used today to meet stationary energy needs will remain the largest contributors to the fuels portfolio in 2025. Therefore, it is important that policies and programs be adopted to maximize the positive attributes of each fuel and minimize the negative characteristics of each fuel.

From a policy perspective, each of the fuels and technologies identified in the previous chapter affects the National Consumer Priorities outlined in Chapter One in different ways. Chapter Two shows that demand for all fuels will grow. Chapter Six describes in detail the characteristics, costs and benefits of each fuel. The goal is to optimize the future fuels portfolio through research and development, investment incentives, and other policy measures.

One of the most important objectives of the CECA Fuels and Technologies Forum is to identify and discuss the key energy policy issues from the consumer perspective. In four Plenary Sessions and additional Working Group meetings, the issues highlighted in this chapter were identified, discussed, and debated by members of the CECA Forum.

This chapter presents the key policy issues identified by the CECA Forum and provides insights into the opportunities for fuels and technologies in stationary applications and the challenges they pose for decision makers. This chapter attempts to provide a course of action to overcome those obstacles, discusses the pros and cons of various policy approaches, and presents the CECA Forum's findings.

This chapter is not intended to provide a comprehensive listing of all issues confronting policymakers as they make energy policy decisions; rather, it focuses on those highest priority issues that members of the CECA Forum believed should command the greatest attention. These issues can confound the nation's energy future, delaying needed investments, increasing costs to consumers, and jeopardizing our energy security.

For purposes of discussion, this chapter is organized into four areas of fuel supply and technology: (1) fossil fuels, including coal, gas, oil, and distributed generation and combined heat and power; (2) nuclear energy; (3) renewable energy resources, including hydropower, wind power, solar power, and other renewable resources; and (4) energy efficiency. It is important to note that the members of the CECA Forum considered energy efficiency in a similar vein to any of the fuels in the portfolio. Therefore, in examining fuels and technologies policy issues, energy efficiency is included as a fuel source. For each fuel source, the chapter concludes with a series of CECA Forum findings.

## 3.1 Fossil Fuels: Key Policy Issues

Coal, natural gas, and oil, the fossil fuels, supply over 80 percent of the current energy needs of the stationary sector. As pointed out in Chapter Two, demand for these fossil fuels is projected to grow significantly over the next 20 years. However, one of the overriding considerations in discussing the future role of fossil fuels in the stationary sector is supply availability. Focusing on the supply side of the supply/demand equation entails a focus on the hurdles that need to be overcome to ensure the supply can meet the projected demand, including infrastructure investments, dependencies on other resources, non-economic constraints in supply, compliance with environmental requirements, and regulatory actions that may result in reduced efficiency or constraints on fuel use. Supply side constraints, if left unresolved, can affect the price consumers will have to pay to meet their future energy needs.

## Coal: Key Policy Issues

Coal is the nation's most abundant fuel source and the U.S. will continue to depend on coal to play a critical role in meeting future domestic energy demand growth. Coal represents one of the most affordable energy sources for consumers and coal prices have been relatively stable. With proven reserves estimated at 250 years at current consumption levels, coal represents a dependable and abundantly available domestic resource. Coal has proven to be a reliable source of high quality energy, fueling over half of the nation's current electricity generation capability.

However, coal also has substantial environmental challenges, which may accumulate as the domestic and global coal resource base and infrastructure grows. In addition to NOx and $SO_2$, two of the Clean Air Act's criteria pollutants, coal, with the highest carbon to energy ratio among fossil fuels, faces another environmental challenge—mercury, a focus of new clean air regulations. Much of the technology development in recent years has been designed to address these environmental challenges. As a result, a new generation of coal-fired power generation systems is ready for demonstration and deployment, while the use of coal as a substitute for high priced natural gas in the industrial sector is now being explored. Additional research into more efficient environmental control technologies, including carbon capture, and in understanding the geologic and chemical implications of carbon sequestration is also underway.

Recent regulatory actions have tightened the amounts of NOx and $SO_2$ that can be emitted by coal plants. In March 2005, the U.S. Environmental Protection Agency (EPA) issued the Clean Air Interstate Rule (CAIR). CAIR applies to the Eastern half of the country and reduces both $SO_2$ and NOx in two phases, 2010 and 2015 for $SO_2$, and 2009 and 2015 for NOx.1 EPA has created an emissions budget for each State that chooses to achieve its emissions reduction requirements based on reductions from electrical generating units and creates parallel emissions reduction targets for States that choose to control other source categories. States can participate in an optional cap-and-trade program similar to the current Acid Rain Program for $SO_2$ and the NOx State Implementation Plan (SIP) Call.

EPA has also taken steps to address mercury emissions from electric power plants. Mercury is a neurotoxin that has serious long-term adverse health effects. The Clean Air Mercury Rule, promulgated by EPA in 2005, is national in scope and sets a national limit on mercury emissions from electrical generating units in two steps: 38 tons in 2010 and 15 tons in 2018. The reductions in the first phase are to be achieved as co-benefits from increased NOx and $SO_2$ reduction efforts through CAIR; however, reductions for meeting the second phase will require additional mercury capture technologies. States may opt to participate in a cap-and-trade scheme. Caps are set at the State level.

Since mercury can be transported in the atmosphere for thousands of miles, the emissions of mercury are not just a national problem, but a global one. More than half of local mercury emissions enter the global mercury cycle and scientific evidence indicates that foreign sources of mercury are contributing to deposition in the U.S. As a global problem, U.S. consumers would benefit from national mercury mitigation policies that are complemented by international efforts. The U.S. can play a significant role in providing international leadership in addressing this global issue.

### *Clean Coal: Opportunities and Barriers*

As indicated in Chapter Two, the environmental profile of coal, including its role in the climate debate, will have a strong impact on its future use. Because of its carbon/energy ratio, developing clean coal technologies, including carbon capture and storage, is key to expanded use of coal in the nation's future energy portfolio. To best meet consumer and environmental requirements, the market for coal infrastructure growth will need to be dominated by the most environmentally friendly advanced coal technologies available. In that regard, it is important that the entire life cycle of coal processes, from coal mining and pre-combustion processes through stack emissions, be considered.

For example, one environmentally-friendly clean coal pre-combustion technology, coal beneficiation, treats coal in such a way as to reduce water content, thus increasing the efficiency of the coal. When the beneficiation is accomplished under pressure, significant quantities of mercury and other impurities are removed in the water and emissions of sulfur dioxide and nitrogen oxides are reduced. However, in recent years, research, development, and deployment funding has been stagnant and the level of funding has been inadequate for demonstration of clean coal technologies focusing on pre-combustion processes.

When passing the Energy Policy Act of 2005, Congress recognized that research and development in carbon capture and storage technologies was an essential step in ensuring that the benefits of coal could be realized in the future. The Act, which allocated funding targets for clean coal technology R&D, also included incentives for deployment of more climate-friendly technologies. Several provisions were specifically designed to address the business risk associated with significant investments in new technologies.

For example, there are currently only two IGCC power generation plants in the U.S. and four globally. Industry

1 Proposed Rule (69 FR 32684) June 10, 2004.

**Table 2: Opportunities and Barriers for Coal**

| Coal Opportunities and Barriers | |
|---|---|
| **Opportunities for Greater Utilization of Coal** | • Clean coal technologies (in particular IGCC, FutureGen, carbon capture and sequestration) will remove environmental and climate change challenges from coal's profile, which will allow coal's clear advantages—in price, abundance, and domestic economic impact—to meet the full set of National Consumer Priorities.<br>• Greater opportunities exist to use coal in industrial processes and transportation applications. |
| **Barriers to Greater Utilization of Coal** | • While the Energy Policy Act of 2005 allocates funding to clean coal R&D priorities, under-funded appropriations could block progress.<br>• The business risk associated with deploying a first-of-its-kind technology can delay large-scale deployment of new clean coal technologies.<br>• Focusing primarily on the power generation sector can result in missed opportunities for expanded use of coal in the industrial and transportation sectors. |

suggests that at least four to six additional plants will be required to overcome concerns about performance and cost through actual operating experiences. Even four to six plants may be insufficient without more standardization in the plant design.[2] This business risk results in higher expectations of return on equity by the investors, thus driving up the cost of such plants and in turn increasing the price of electricity to consumers. The Energy Policy Act of 2005 recognizes the potential importance of converting coal to liquid fuels such as diesel and gasoline and coal to gas for industrial uses. Research in coal to liquid technologies could play a critical role in supplying domestically produced transportation fuels in the future, while research into coal to gas can provide the industrial sector with a substitute for high priced natural gas.

Finally, DOE has embarked on the development of a near-zero emissions coal-fired power plant, referred to as FutureGen. FutureGen is a public-private partnership involving many of the largest coal producers and users. FutureGen will demonstrate the latest technologies for development of hydrogen, carbon sequestration, gasification, and other research necessary for meeting our future coal-related energy needs.

Although the Energy Policy Act of 2005 takes a strong step forward in promoting the next generation of coal-fired power production, it does not equally promote all potentially viable advanced coal technologies. Nor are many of these incentives applicable to rural electric cooperatives or other non-tax paying entities. In recent years, research, development and deployment funding has been stagnant and inadequate for demonstration of clean coal technologies focusing on approaches such as pre-combustion solutions. Pre-combustion clean coal methods are not widely used and research and development funds are needed to expand such clean coal technologies.

2 GE and Bechtel are working on a standard design based on the GE gasification technology (formerly the Texaco process); however, the multiplicity of gasification technologies available and under development complicates the marketing of a standard plant design.

## CECA Forum Findings on Coal

The CECA Forum found that the positive attributes of coal indicate that it will be an important part of the fuels portfolio through the 2025 timeframe of the CECA study. In addition, one of the most challenging National Consumer Priorities for coal—that of environmental responsibility—could be satisfactorily addressed through advances in new technologies. Further, the CECA Forum found that:

- In recent years funding for coal sequestration R&D has been stagnant and there has been inadequate funding for demonstration of clean coal technologies.
- The breadth of technologies available will allow users the flexibility to reduce environmental impacts at the pre-combustion stage (i.e., coal beneficiation), post-combustion (emissions-capture technologies), or a combination (IGCC).
- Clean coal technologies may have significant co-benefits, such as the production of electricity, hydrogen, and industrial grade chemicals and minerals, and may represent a viable alternative to high priced natural gas for much of the nation's industrial applications.
- Technologies that reduce or mitigate greenhouse gas emissions, such as IGCC and sequestration, are critical to meeting the nation's shared climate goals.
- The Federal government should take a leadership role in addressing the global problem of airborne mercury and engaging the international community in developing a global strategy for the reduction of international transport of airborne mercury. The U.S should take the lead in developing a global cap-and-trade or other market-based mechanisms for reducing the emissions of mercury.

- In addition to research designed to address climate-related issues associated with coal use, increased research and development is necessary to improve environmental and overall performance of the existing power generation fleet in the U.S., as well as into alternative uses of coal to help alleviate impacts from high oil and natural gas prices and constrained gas supply.

## Natural Gas: Key Policy Issues

Natural gas is a major source of energy for all stationary energy needs. Its positive environmental attributes have been a key factor in the increasing reliance on gas by the power generation sector. It remains a major feedstock and a source of process steam and heat for the industrial sector and is a significant fuel for heating and cooling for the residential and commercial sectors.

However, the volatility and escalating prices of natural gas have had significant impacts on consumers' heating costs and electric bills. Likewise, recent increases in the price of natural gas have had devastating impacts on the chemical and other industries that use natural gas as a feedstock, have contributed to significant employment losses in those sectors in the U.S., and have resulted in the relocation of U.S. industrial facilities abroad.[3]

The continued growth of natural gas-fired electricity capacity to address the projected growth in electricity demand may be limited due to issues of availability and price. Natural gas has been one of the most volatile of the energy fuels in recent years. With the recent high prices of natural gas, investors face a higher level of risk in new projects. From a consumer perspective, this translates into higher prices and delays or deferrals of much needed electric generation capacity, with the potential for use of less efficient and more costly capacity.

### *Domestic Natural Gas: Opportunities and Barriers*

A significant reason for these price concerns is due to projected supply constraints in the North American market. Unlike oil, natural gas is not easily traded on the global markets. Thus, the supply questions in the North American market dominate the issues relating to natural gas. In 2003, the National Petroleum Council (NPC) projected a 25 percent shortfall in supply of natural gas from conventional sources compared to projected demand in 2025.[4] Similarly, the EIA projected an 8.7 trillion cubic-foot (tcf) gap in domestic natural gas production by 2025.[5] As recently evidenced, the market has tightened much sooner than expected, exacerbated by a decline in imports from Canada, which are forecast to decrease to 2.6 tcf by 2025 due to both the depletion of resources as well as Canada's own increasing demand.

Proven reserves of natural gas from Alaska's North Slope are estimated at 35 tcf. Most of this gas is in onshore fields and mostly beneath State of Alaska surface or submerged lands. No Federal offshore gas reserves are considered to be readily available for export at present. Ninety-seven percent (26 tcf) of Alaska's exportable gas reserves occur within fields in or near the Prudhoe Bay field in Northern Alaska. The Prudhoe Bay area gas reserve base totals 30.9 tcf, but some of this gas will be consumed (at the current rate 0.2 tcf/yr) by future oil and gas production activities at Prudhoe Bay. The stranded gas reserves at Prudhoe Bay are presently attracting proposals for construction of a gas transportation system that can take the natural gas to markets outside of Alaska.

Across Alaska and the Alaskan offshore area, unconventional sources of natural gas, such as gas hydrates and coal bed methane, are estimated to contain up to 170,000 tcf of natural gas. Most of this resource is contained in methane hydrates – gas that is trapped in marine sediment – located far offshore in water depths exceeding 300 meters and will remain inaccessible for the foreseeable future. However, 37 to 44 tcf of gas are estimated to occur in sub-permafrost gas hydrates in and around oil fields developed in the Prudhoe Bay and might be exploited on an experimental basis once a gas transportation infrastructure is installed. The United States Geological Survey (USGS) estimates the in-place gas resource within the United States at around 200,000 tcf.[6] Developing this resource in an environmentally sound manner requires a significant investment in data gathering, drilling and production techniques, and an assessment of the impact of hydrate development on the environment.

However, moving natural gas from Alaska to the regions of the U.S. that need the supply requires an estimated $20 billion construction project on the part of the private sector, including upwards of 1600 miles of steel pipe just to get gas from the North Slope. To date, progress has not been forthcoming. In the Energy Policy Act of 2005, Congress signaled its interest in expediting the development of the Alaska Natural Gas Pipeline by requiring the Federal Energy Regulatory Commission (FERC) to report regularly on the

3 EIA, "Issues in Focus," *Annual Energy Outlook*, 2006. DOE is conducting research on the potential for gasification developed syngas as a substitute for industrial processes, as well as identifying other fuel substitutes as a means of reducing the economic impact of rising natural gas prices on the nation's industrial sector.

4 "Balancing Natural Gas Policy – Fueling the Demands of a Growing Economy," National Petroleum Council, 2003.

5 EIA, *Annual Energy Outlook*, 2005.

6 Department of Energy Fossil Energy Program, *Methane Hydrate - The Gas Resource of the Future*, based on 1995 U.S. Geological Survey study as updated in 1997.

status of the project. In addition, the State of Alaska is in active discussions with potential project developers.

Congress directed the development of a new ultra-deep water and non-conventional gas program in the Energy Policy Act of 2005. Unconventional onshore gas resources include coal bed methane, tight sands gas, gas shale, and gas produced from very deep formations. This new program is projected to produce an additional 3.8 tcf.[7]

## *Imported Liquefied Natural Gas: Opportunities and Barriers*

LNG is emerging as the most significant and controversial issue in natural gas supply. Importation of LNG would give the U.S. access to natural gas resources throughout the world. Imported LNG is the source of natural gas that has the potential to be developed most rapidly to meet the shortfall. Some argue that without access to the larger supply of worldwide natural gas made possible by the importation of LNG, the U.S. will face higher natural gas prices and be more susceptible to unexpected supply shortfalls. Others contend, however, that world demand for LNG from China and other fast growing economies could move the price of LNG higher on the global market and U.S. domestic gas prices would rise to match those levels. Even if imported LNG were to lower prices temporarily, some suggest additional demand would drive prices back up. Further concerns about safety and siting of LNG facilities could seriously impact the role LNG plays in the U.S.

The U.S. competes in the world markets for its increased LNG share. The Organization for Economic Cooperation and Development (OECD) countries increasingly import gas and all OECD regions are now dependent on imports. With growing import dependence worldwide, there has emerged the necessity for greater awareness of gas policies in supplier countries and along transit routes. The concentration of new LNG supplies in non-OECD countries adds a geopolitical dimension to the security of LNG supply. Additionally, gas-fired power generation is fast emerging as a new global driver of gas demand, representing 70 percent of the projected increase in demand in OECD countries over the period 2000-2030 and over 50 percent of the projected increase in demand in the U.S. While increased links between open gas and electricity markets offer the chance for more efficient use of both systems, growing use of imported gas for electricity generation emerges as a new issue for security of supply for electricity.

The concurrent opening of gas and electricity markets worldwide changes the environment for security of gas supply. In open markets, supply and demand are balanced by market mechanisms. With markets opening, new instruments such as gas hubs, spot, and futures markets evolve, allowing gas to be directed to its highest value use. The challenge for security of supply is to enable markets to achieve this supply/demand balance and provide adequate investment all along the gas chain in a timely and coordinated way. Cost reductions in the LNG chain also result in more flexibility and a global reach of LNG trade, again enabling LNG supplies to be directed to their highest value market, adding to the security of gas supply. Open gas markets substantially improve security and reliability of gas supplies, but governments must continue to play an important role to make markets work. The role of government, which in the past often directly or indirectly managed the sector, is now to define roles and responsibilities of key players and set rules enabling efficient markets to deliver reliable gas supplies to final customers.

Traditional LNG contracts have been long-term (20 years) and have had various restrictions. In the coming decade, many LNG contracts will expire and will come up for renegotiation. A trend is developing toward more flexible contracts, including less rigid pricing, shorter terms, more delivery flexibility, and less strict take-or-pay provisions. This market shift is being made possible by a growing LNG market, with more suppliers and buyers, uncommitted production capacity, and underutilized transportation capacity. Although challenging, international LNG suppliers are adapting traditional contracting approaches to U.S. market realities which potentially include floating prices tied to Henry Hub, where New York Mercantile Exchange (NYMEX) futures contracts are traded, open access transportation rules, and limited use of long-term contracts with quantity commitments.

Today in the U.S., 96 LNG liquefaction, storage, and regasification plants operate in 29 States and LNG tanker trucks are a common site on many highways. By the same token, LNG projects are essentially large industrial facilities that can have local impacts on terrestrial, marine, air and scenic resources. Some of the risks associated with LNG may be reduced through design, operations, and location. Currently one of the more controversial practices is called open loop vaporization (OLV), whereby millions of gallons of seawater are drawn into the facility, chlorinated, used to warm the gas from its liquefied state, and then discharged back into the ocean. Critics assert that the practice damages marine life due to the discharge of the large quantity of cold, chlorinated (sterilized) water. Others counter that the practice has a minimal effect on marine fisheries. Both sides in this debate have contracted studies to bolster their arguments.

7 Gas Technology Institute Fact Sheet, *Ultra Deepwater and Unconventional Natural Gas and Other Petroleum Supply R&D Program*, www.gastechnology.org, accessed January 31, 2006.

**Table 3: Opportunities and Barriers for Natural Gas**

| Natural Gas Opportunities and Barriers | |
|---|---|
| **Opportunities for Greater Utilization of Natural Gas** | • As the environmentally friendliest fossil fuel available, natural gas is an important fuel in meeting increasingly stringent air quality requirements.<br>• Because of its higher heat content, gas can be used in electricity co-generation facilities, whereby the efficiencies are much higher.<br>• Natural gas is a valuable component of home heating and industrial processes. |
| **Barriers to Greater Utilization of Natural Gas** | • The difficulty of storing and transporting (compared to liquid or solid fuels) means that some supplies are stranded (e.g., in Alaska).<br>• Demand is increasing from electricity generators, domestic heating, and industrial processes, causing a tightening of supplies and price impacts.<br>• Escalating prices of natural gas and constrained supply have resulted in abandoned gas-fired generation facilities and have caused U.S. industries to locate abroad.<br>• North American production from conventional sources will not be sufficient to meet demand over the next 20 years.<br>• Barriers to LNG include strong environmental regulations, local opposition to facility siting, and technical issues regarding the interchangeability of LNG and domestically produced gas. |

The National Oceanic and Atmospheric Administration (NOAA) recommends that this practice be avoided.[8]

At the same time, LNG plant construction may have significant economic benefits for local economies in the form of increased employment, local expenditures, and taxes. Through the Energy Policy Act of 2005, FERC has jurisdiction for reviewing and approving *on-shore* LNG plant proposals and has implemented an extensive environmental review process that puts a premium on public communication and the input of Federal, State and local agencies. The U.S. Coast Guard is the lead agency for reviewing *off-shore* LNG plant proposals. State governors have a significant role in the Coast Guard's decision making process. Although significant progress has been made to streamline the LNG permitting process, it remains complex and lengthy. It may take up to seven years to bring a new onshore terminal on-line, from initial design to the first delivery of LNG imports, including up to three years for obtaining necessary permits and approvals.[9]

In terms of siting LNG facilities, there are legitimate concerns that the licensing approach undertaken by State and Federal regulators is inefficient. By taking a comprehensive approach to siting and licensing issues, some suggest it may be possible to streamline the approach for licensing LNG facilities. Others raise concerns about streamlining regulatory approaches, pointing out that the regulatory process needs sufficient time for public comment and due consideration of social, environmental, and safety issues.

From a policy perspective, there are reasons for considering incentives to maintain a geographic dispersal of LNG facilities in order to avoid potential vulnerabilities and attendant supply and price implications associated with significant concentration of LNG facilities in one area of the country. On the other hand, some point to the availability of the existing natural gas infrastructure as a countervailing argument to dispersal. Additionally, while the Energy Policy Act of 2005 provides FERC with jurisdiction over siting of LNG terminals on shore, FERC is obligated to address any safety issues raised by a State agency. Recently, the California Energy Commission issued a Safety Report on the Long Beach LNG project, raising the issue of siting in the vicinity of populated areas. The report posits that placement of such a facility in a densely populated high-impact area must not occur until a comprehensive risk, economic, and fiscal impact assessment is complete. Clearly FERC will have to address similar issues in other locations, where it will be expected to establish clear LNG siting criteria after a thorough stakeholder process and encourage developers to continually involve and educate local community representatives.

Another challenge to LNG is supply interchangeability, which is defined as the ability to substitute one gas supply for another without impacting the safety, reliability, or efficiency of end-use applications. LNG imports typically have some degree of molecular differences compared to traditional pipeline supplies, such as a higher heating value. However, these small differences can be significant enough to make interchangeability of gas supplies more difficult. To meet the interchangeability challenge, LNG can be blended either with other "leaner" pipeline supplies or through the introduction of inert gases, such as nitrogen, to resemble domestic natural gas. Interchangeability issues with certain LNG imports can also be managed at the supply source by removing non-methane constituents, thus producing a product that better resembles domestic pipeline natural gas.

8 Memo from NOAA Science Administrator, Nancy B. Thompson, February 18, 2004, accessed at http://sero.nmfs.noaa.gov/dhc/lng/lng_ws_memo.pdf on March 4, 2006.

9 National Petroleum Council, LNG Subgroup Report, August 2004.

## CECA Forum Findings on Natural Gas

There is no question that natural gas plays an essential role in the portfolio of fuels needed to meet stationary energy needs. Because of it characteristics and versatility, it is the one fuel that is in high demand across the spectrum of stationary energy applications, including domestic heating, chemical and manufacturing processes, and electricity generation. The CECA Forum found that:

- Because of the importance of maintaining a domestic supply of natural gas, transportation capacity is needed to bring the Prudhoe Bay reserves in Alaska to load centers in the continental U.S. Beyond Alaska, it will be increasingly important to look to ultra deep gas resources and other non-conventional sources of natural gas such as coal-based syngas and coal bed methane.
- Until advanced emissions-reduction technologies are available for coal, gas remains the preferred fossil fuel for electricity generation from an environmental standpoint, although price and supply constraints of natural gas are offsetting factors. Once clean coal, carbon capture and sequestration, and other emissions-limiting technologies become more widely available, the environmental advantage of natural gas will diminish.
- There is a need to ensure that LNG, when re-gasified, is compatible with the existing natural gas infrastructure and end-use equipment.
- The disproportionate concentration of natural gas facilities in the Gulf of Mexico creates a supply risk during times of severe disruption, as demonstrated by Hurricanes Katrina and Rita in 2005.
- Research is needed for affordable natural gas substitutes to ensure the sustainability of the nation's critical industrial sector.

## Petroleum and Oil for Home Heating: Key Policy Issues

Residential heating constitutes the largest non-transportation use of distillate fuels, with nearly 10 percent of households in the United States heating their homes with oil. Oil usage for heating is primarily focused on the residential sector (only four percent of commercial facilities heat with oil) and nearly 80 percent of the 8.1 million households that heat with oil reside in the Northeastern region of the country. It is the most tangible fuel for consumers, as heating oil dealers have a direct relationship with their customers, deliver fuel to the home, provide maintenance advice, and service the equipment.

Oil has a small market in new home construction, and the industry is attempting to expand the conversion of electric-heated homes to oil and some conversion of natural gas to oil is also taking place. In 2001, about 6.6 billion gallons of heating oil were sold across the country, with 82 percent sold to consumers in the Northeast. This represents approximately two percent of annual consumption of crude oil in the United States.

### *Petroleum and Oil for Home Heating: Opportunities and Barriers*

From a policy perspective, although environmental restrictions have not been placed on heating oil per se, the EPA has placed strict controls on the sulfur content of distillate fuels used for transportation (on-road) and the heating oil industry has voluntarily adopted the goal of providing low sulfur heating oil (0.05 percent sulfur content). This is a significant reduction and equivalent to on-road requirements for at least 80 percent of heating oil customers. This self-imposed environmental goal demonstrates the home heating oil industry's initiative in taking the necessary steps to adapt to new environmental conditions while remaining self-regulated.

Heating oil is often the center of yearly legislative attention because of the number of low-income residents that need Federal and State subsidies for the purchase of fuel. The Energy Information Agency recently revised upward its 25 year oil price projections significantly based on evidence of tightening global supplies as a result of strong demand growth in developing countries. The retail prices for heating oil over the next 25 years will reflect the upward price pressure. In 2005 Hurricanes Rita and Katrina affected the supply of oil and natural gas coming out of the Gulf of Mexico, further exacerbating prices.

The Low Income Home Energy Assistance Program (LIHEAP), initially authorized by Title XXVI of the Omnibus Budget Reconciliation Act of 1981, began distributing funds as block grants to States in 1982.[10] The program is funded through the appropriations process in Congress, meaning that the actual amount varies from year to year, making it difficult for States to plan how to provide assistance to low income households. Since heating oil is a vital fuel for heating in the Northeast, the purchase and distribution of oil for low-income consumers is impacted by the yearly allocation of funding for LIHEAP.

The relationship between heating oil and biofuels (primarily biodiesel, a fuel derived from vegetable oil) is growing, and is one that has clear policy implications. In composition,

10 From Campaign for Home Energy Assistance webpage, at http://www.liheap.org/background.html, accessed on March 2, 2006.

**Table 4: Opportunities and Barriers for Home Heating Oil**

| Home Heating Oil Opportunities and Barriers | |
|---|---|
| **Opportunities for Greater Utilization of Heating Oil and Biofuels** | • Heating oil is the most tangible of all fuels for residential consumers, since heating oil dealers have a direct relationship with customers, deliver fuel to the home, and service the equipment.<br>• With the emergence of heating oil/biodiesel blends (bioheat), there is an opportunity to improve significantly oil's environmental profile while maintaining its price competitiveness and convenience of distribution.<br>• Bioheat offers an opportunity to hedge against price swings, protecting consumers from harmful spikes.<br>• Bioheat provides opportunities for economic development domestically in areas where biodiesel can be grown and processed.<br>• There are opportunities to reevaluate the method by which heating efficiency is measured so that consumers, regulators, and the industry benefit from a more accurate understanding of heating efficiency. |
| **Barriers to Greater Utilization of Heating Oil and Biofuels** | • Biodiesel in higher blends could somewhat increase the cost of fuel.<br>• Developing an alternative to AFUE and creating a unified, national standard will entail significant research and development by research institutions, national labs, and industry. Resistance to new metrics, as well as re-training technicians to utilize the new system, may slow the adoption of the new standard once it has been developed. |

heating oil and biodiesel are similar enough that they can be blended together at any level up to 20 percent without any discernable difference in performance. The two fuels can be blended to higher levels as well,[11] and while some heating oil dealers sell straight biodiesel (B-100) as a premium fuel, it is typically blended at levels from two percent to 20 percent.[12] A policy implication of this trend is that government promotion of renewable biofuels for heating through tax credits, rebates, or other incentives will have the effect of increasing the use of biofuels in heating oil as well. An additional consideration is that the blending of heating oil and biofuels helps hedge against price spikes and fluctuations. During particularly severe winters, prices for heating fuels can increase over a short time span. Finally, biofuels are produced primarily in North America, providing economic benefits for local economies, the agricultural sector, and for a growing segment of industry dedicated to converting and processing this fuel.

From a technology standpoint, a better understanding of home energy consumption, including heating and hot water systems, is warranted. Studies show that in many cases relatively low-cost efficiency measures, such as ceiling and wall insulation, weather-stripping around windows and doors, and automatic thermostats, as well as investment in high efficiency equipment, can produce significant energy savings.[13] The Annual Fuel Utilization Efficiency (AFUE) rating system—which calculates the efficiency of the heating system by measuring the amount of heat delivered against the amount of fuel supplied—provides useful information, but industry and efficiency experts believe that the current AFUE system is incomplete and not a realistic predictor of actual home energy use. There is a need to develop an improved rating system to be used by regulators and the home heating industries in order to provide better information on reducing consumption.

## CECA Forum Findings on Petroleum and Oil for Home Heating

The CECA Forum found that heating oil currently plays a positive role in domestic heating. It provides consumers an alternative and often cost-effective option to the slate of heating fuels that include natural gas and electricity. It is the most tangible fuel for consumers and consumers benefit from a direct relationship with their heating oil dealer who delivers fuel oil, services the equipment, and often provides efficiency advice. The CECA Forum found that the option to blend heating oil and biodiesel will provide consumers with another positive and environmentally-friendly choice. More specifically, the CECA Forum found that:

11 Higher blends of biodiesel may entail minor modifications or upgrades of heating and fuel storage equipment.

12 The industry has adopted the term "bioheat" to refer to the blended product of biodiesel and heating oil.

13 Since 1980, CECA has produced a series of brochures for consumers identifying ways to improve the efficiency of their home and their heating equipment and thereby reduce heating oil bills. See, Consumer Energy Council of America, Washington, DC, *Smart Choices for Consumers: Analysis of the Best Ways to Reduce High Heating Costs*, November 2005; *Oil, Gas, or …?. An Evaluation of the Economics of Fuel Switching Versus Home Energy Conservation*, March 2001; *Oil, Gas, or …?. Technical Support Document for a Consumer Decision Making Guide on Fuel Switching and Home Energy Conservation*, January 1994; *Technical Support Document for a Consumer Decision Making Guide on Fuel Switching and Home Energy Conservation*, August 1991; *Technical Support Document for a Consumer Decision Making Guide on Fuel Switching*, May 1989; *An Analysis of the Economics of Fuel Switching Versus Conservation for the Residential Heating Oil Consumer*, October 1980 at www.cecarf.org . See also energy efficiency studies by the American Council for an Energy-Efficient Economy at www.aceee.org and the Alliance to Save Energy at www.ase.org.

- Price volatility of heating oil during the winter months may be mitigated through increased use of biodiesel.

- The increased use of low sulfur heating oil, along with the growing distribution network for biofuels, will have a positive impact on the environment.

- A wide variety of relatively low cost efficiency measures, such as ceiling and wall insulation, weather stripping around windows and doors, automatic thermostats, and high efficiency equipment can save significant amounts of energy with consequent reductions in consumers' heating bills.

- The development of testing and standards procedures to improve the AFUE rating system could provide more accurate information on the efficiency of home heating systems, leading to better use of equipment, better purchasing decisions by consumers, and greater reductions in energy use.

## Distributed Generation and Combined Heat and Power: Key Policy Issues

Distributed generation (DG) refers to small, modular electricity generators sited close to or at the point of customer load. Some DG technologies take advantage of being close to the customer load by capturing and utilizing the heat released from electricity generation that would otherwise be wasted. Known as co-generation or combined heat and power (CHP), this is the largest potential method of generating electricity from distributed resources. Independent of whether the primary purpose is to generate heat or to generate electricity, when these two services are combined, it is labeled CHP, and is known for a particularly high level of efficiency. CHP can utilize high efficiency gas turbines or more exotic technologies such as large fuel cells, which generate enough heat to be captured and used. Other technologies, such as small wind power facilities, photovoltaic, or back-up generators fall into the DG category since the energy is generated close to the point of use.

The average efficiency of power generation in the U.S. has remained around 33 percent since 1960, meaning that 67 percent of the fuel consumed in electricity generation is typically wasted in the form of heat loss. In the U.S., the thermal losses in power plants totaled almost 23 quadrillion BTU's of energy in 1997, representing over 24 percent of total U.S. energy consumption. Approximately seven to eight percent of the nation's current national electricity supply comes from CHP.[14] Theoretical efficiencies of a CHP system can approach 85 percent; more typical efficiencies range from 55 to 70 percent, compared to efficiencies of 28 to 35 percent for traditional utility boiler systems, and 37 to 41 percent efficiency for newer centralized technologies such as super-critical units.

### *Distributed Generation and Combined Heat and Power: Opportunities and Barriers*

In the appropriate situations, there is substantial value from the distributed energy model that can complement and supplement the centralized model. For example, under the right conditions, DG can enable utilities to defer or eliminate costly investments in transmission and distribution (T&D) system upgrades, concentrate on peaking units rather than baseload capacity, and extend the energy from fuel supplies. There are many consumer benefits that DG can provide as a complement to central station power. DG can incorporate environmentally-responsible sources of energy, such as wind power, solar power, and biomass. DG can provide customers with higher quality power, increased reliability, and potentially lower costs of electricity to consumers. On the other hand, when fuels such as diesel are used in distributed generation, it can be difficult to regulate pollution output from many small point sources. On balance there are strong opportunities for DG to complement energy produced from central power facilities.

### Economic and Technical Considerations

A primary issue in bringing a DG/CHP project to fruition is determining how a given investment will perform for shareholders, and how the generation will impact consumers' utility bills. In many cases, a well-targeted and rigorously executed DG/CHP investment can have positive effects on consumer energy bills, particularly where power quality or reliability are of paramount importance. There are ownership considerations regarding who would carry the unit on their balance sheet: a utility, a third party developer, or the primary customer. Furthermore, there are external characteristics which impact the economics of the project, as well, and which must be evaluated, including tax implications, prevailing fuel prices, and issues related to interconnection standards.

Factors to consider in the cost analysis include the value of higher delivered (T&D) efficiency, peak-shaving, and potential environmental characteristics, as well as

14 Energy and Environmental Analysis, Inc. maintains a database for DOE that shows CHP capacity is about eight percent of U.S. generating capacity. Though generation is not tracked, the assumption is that capacity factors for CHP facilities are higher, on average, than for non-CHP generators.

demonstrable higher power quality and power reliability for certain customers or applications. These factors can result in DG/CHP providing attractive returns on investment for an independent developer or utility, while providing additional value to multiple classes of consumers. A problem in considering these factors is the fact that they may be viewed as intangibles and difficult to value or translate into real dollars. Therefore these positive attributes may not be sufficiently factored into the analysis and this could negatively impact a CHP project's viability.

Technical issues fall into two categories: ones that involve actual engineering at the site, and ones that involve proper integration of DG into the national electric grid. The site engineering issues, while often complicated, are typically overcome. Grid interconnection issues, on the other hand, are more complex and have implications on safety, reliability, and power quality of the grid. Interconnection standards are necessary for a variety of cost and reliability reasons, and due to the potential for reverse power flows or "islanding," safety of utility personnel and electronic equipment is the preeminent issue. Several States have developed (or are developing) their own interconnection standards for DG and CHP, and FERC has adopted IEEE SCC21 P1547 as a national standard for interconnecting distributed energy resources with electric power systems.

Real-time information and system control technologies, including control systems which permit utilities to remotely control a customer's electrical equipment, will facilitate the integration of distributed power systems into the electricity grid. Advances in extremely reliable power electronics have decreased the level of utilities' concern regarding safety and power quality, and the interconnection standard should decrease it further. The need for network operators to manage the grid more actively will grow. While this will add complexity it will also help the grid operate more efficiently as a network.

## Policy Considerations

In the next few years, many companies will face decisions to replace, retire, or refurbish aging power plants, industrial boilers, and heating, ventilation and air conditioning (HVAC) systems, and this presents an opportunity for policymakers to strengthen the nation's infrastructure and provide benefits for consumers. There are a variety of regulatory policy and institutional factors which constrain the development of cost-effective and competitive CHP systems compared to central station power plants. Equitable policies regarding interconnection to the grid, distribution and metering of the power produced by DG, ability to trade power on the open market, equitable environmental permitting, and even tax depreciation are necessary to allow DG to compete in the marketplace. New legislation or updated and improved regulations may have significant impacts on the growth of DG resources over the next 20 years.

The differences in State regulations have the most serious impact on the viability of DG. Roughly half of the States have undergone certain measures in restructuring their electric utility industries, and these changes play a large role in DG development. For example, there is a substantial difference between the analysis done by an independent power producer in a restructured State versus the classic ratepayer-based economics a utility performs to justify its rates to a State Public Utility Commission, in which CHP is less attractive. Some States also include provisions, such as net metering, by which a DG application that produces more power than it consumes can "sell" a certain amount of power back to the grid. From an economic point of view, the higher efficiency of some DG units can lower energy bills if there is a substantial thermal load at the facility. Since the optimal (efficiency) sizing of CHP systems often necessitates generation in excess of the internal needs of a facility, permitting opportunities to sell the excess power are essential for designing a project to reach the highest level of fuel utilization and efficiency.

As transmission and distribution systems are a focus of State, Regional, and Federal regulation, the benefits to the grid that result from widespread use of DG should also be a focus of regulators. Under the right circumstances, distributed energy resources can defer or eliminate the need for T&D additions or line upgrades required to serve a new load, and since capacity and asset replacement costs constitute between 25 and 35 percent of many utilities' capital improvement budgets, the potential benefit to ratepayers is substantial. The management of peak load demand, congestion relief, and voltage support are important related benefits. In locations where DG/CHP units are installed in lieu of T&D upgrades, there are legitimate concerns surrounding maintenance, operations, and general accountability of generator performance vis-à-vis a utility's regulatory responsibility to provide reliable electricity service to the general public.

There are siting issues regarding space constraints, permitting, and local opposition for which CHP may also provide relief. Reliability and power quality demands are not equal for all customers, and DG/CHP may provide a method of delivering that service for those customers who require it. This, in turn, enables generators to charge higher rates for this reliability. Finally, there are symbiotic opportunities which advance the value of certain renewable energy resources if they are connected to the grid, especially in peak shaving applications, and this also enhances the grid's performance and complements existing State-level Renewable Portfolio Standard objectives.

### CECA Forum Findings on Distributed Generation and Combined Heat and Power

The CECA Forum found that there are significant opportunities for DG and CHP to contribute positively to meeting the nation's stationary energy needs. The CECA Forum also addressed the economic, regulatory, and environmental barriers that must be overcome. More specifically, the CECA Forum found that:

- DG and CHP are most effective in situations that call for a custom solution. In these site-specific situations, the appropriate DG resource may offer superior value compared to other energy resources.
- DG resources, when used in a CHP application, are more effective at utilizing fuel resources because of their higher efficiency ranges and because they eliminate line losses that occur as power is transported over long distances.
- A popular misconception is that all DG resources are environmentally superior to central power resources. While DG includes small renewable energy resources, such as solar photovoltaics (PV), it also includes mobile diesel generators that may produce more pollutants per unit of energy than central power plants. Unlike central station plants, however, the number of hours that diesel generators can operate in a day is limited by pollution control regulations.
- DG should be considered as a portfolio of available technologies that meets a variety of needs in the stationary energy infrastructure.
- Concerns regarding pricing for DG/CHP stem from rate designs that do not provide the appropriate price signals to prospective DG/CHP host facilities, which may obscure the true cost of electricity.

## 3.2 Nuclear Energy: Key Policy Issues

Nuclear energy is a key component of the nation's fuels portfolio to meet stationary energy needs, providing 21 percent of the electricity generated within the United States. Nuclear energy has important attributes. It does not produce greenhouse gas emissions and it is an affordable and reliable source of power. For these reasons, there is renewed interest in nuclear energy's role as a climate-friendly source of power. Congressional support for new nuclear facilities is gaining as evidenced by the incentives provided in the Energy Policy Act of 2005. These incentives are designed, at least in part, to address the capital cost and some of the regulatory uncertainties of nuclear energy – especially for the "first movers."

As shown in Chapter Two, demand for electricity from nuclear technologies is projected to grow significantly over the next 20 years and beyond. However, no new nuclear power plant has been ordered in the U.S. since 1978 and uncertainties surround the revival of a U.S. nuclear power industry. The most significant uncertainties involve cost and the regulatory process, used nuclear fuel management, and concerns about safety and proliferation.

### *Nuclear Energy: Opportunities and Barriers*

There are significant developments that can point the way for an expanded role for nuclear energy in the U.S. The commercial nuclear power industry, with cost-shared support from DOE, has developed advanced light water reactors and is applying for Nuclear Regulatory Commission (NRC) certification. The NRC revised its certification process in the early 1990s and required that safety issues within the scope of the certified designs undergo an extensive public review process prior to certification. Further, the NRC's new plant regulatory process allows utilities to obtain a single license from the NRC before construction begins to both construct and operate the new plant.

**Table 5: Opportunities and Barriers for Distributed Generation and Combined Heat and Power**

| DG/CHP Opportunities and Barriers | |
|---|---|
| **Opportunities for Greater Utilization of DG/CHP Resources** | • The broad portfolio of technologies allows project planners and developers the opportunity to utilize appropriate DG resources in ways that save money and fuel, reduce environmental impacts, and provide greater flexibility for the end user.<br>• DG resources may provide significant opportunities for regulators and grid operators to consider alternative means to grid expansion, peak load, and congestion management. |
| **Barriers to Greater Utilization of DG/CHP Resources** | • DG resources are not suitable for all applications and must be considered on a site-specific basis.<br>• The wide variety of regulatory disparity among States makes it difficult for DG planners to create national strategies or apply lessons learned from one State to the next.<br>• Difficulties remain in safely interconnecting the systems to the grid.<br>• The charges utilities levy to provide standby power remain a barrier to achieving cost competitiveness. |

Because no new nuclear power plants have been built in the U.S. for many years and all new plant designs involve new technology, estimates regarding the cost of new nuclear power plants are uncertain. That uncertainty, coupled with the extra costs associated with a first-of-a-kind facility, led Congress to approve several incentives for the nuclear power industry in the Energy Policy Act of 2005. Electricity produced from a limited number of qualifying advanced nuclear power facilities can receive a limited production tax credit (PTC) of 1.8 cents per kilowatt hour for the first eight years of operation. Six thousand MW allocated to newly constructed nuclear power plants will be eligible for this credit. The Energy Policy Act of 2005 also established a program to provide up to 80 percent Federal loan guarantees for generating facilities, including nuclear energy facilities, that "avoid, reduce, or sequester" the emissions of greenhouse gases.

In recognition of the regulatory uncertainty associated with those elements of the new nuclear plant licensing process that have never been tested, the Energy Policy Act of 2005 also provided standby support for delays in the commencement of full operation of new nuclear facilities due to litigation or to delays in NRC approval beyond the control of the licensee. The support is available for up to six reactors. The first two reactors can receive up to $500 million each and the remaining four reactors can receive up to $250 million each, for a total outlay no greater than $2 billion. Covered costs of delay include principal and interest and the incremental cost of purchased power to replace contracted power from the nuclear facility.

The nuclear energy provisions of the Energy Policy Act of 2005 have important consequences for first movers. The nuclear energy incentives should relieve much of the financial uncertainty in developing a new generation of nuclear power plants. The Price-Anderson Act's liability protection has been extended to 2025, which will alleviate some liability uncertainty. The loan guarantees, tax credits, and, in particular, the stand-by support discussed above are focused on overcoming uncertainties associated with first-of-a-kind technology penetration, such as regulatory and siting uncertainty, and lack of cost and operating experience.

These nuclear energy provisions are intended to boost the nuclear energy industry's investment in new generation facilities and provide incentives to include nuclear energy in the industry's future plans. The Energy Policy Act of 2005 also authorizes a project to develop next generation nuclear power plant technologies in the U.S., referred to as Generation IV technologies or Gen-IV. Provisions are included in this new project to solicit international cooperation, demonstrate nuclear energy's role in hydrogen production, and develop NRC licensing approaches. The target date in the Energy Policy Act of 2005 for commencing operation of a prototype hydrogen generation plant is 2021. Authorization levels are $1.2 billion through 2015.

## Used Nuclear Fuel Management and Recycling

The discharge from reactors after the production of electricity using nuclear energy is termed used nuclear fuel (or spent nuclear fuel). Although the volume of used nuclear fuel is small relative to wastes from other energy production processes, used nuclear fuel is highly hazardous, requiring special equipment and shielding, and careful management.

Under the Nuclear Waste Policy Act of 1982, the Federal government is responsible for permanent disposal of nuclear waste. Essentially, two strategies exist to address the disposal of nuclear waste:

- ***Direct Disposal (once-through fuel cycle)*** - The used nuclear fuel can be put in specially-designed containers, or waste packages, and buried deep underground. The goal is to isolate (store) the used nuclear fuel for tens of thousands of years or more until it becomes significantly less radioactive and hazardous.

  In 2002, after decades of research and deliberation, the Department of Energy moved ahead with this option when it recommended Yucca Mountain in Nevada as the suitable location for an underground repository for used nuclear fuel. U.S. consumers of nuclear-generated electricity have already contributed $24 billion to date towards the repository at Yucca Mountain. Due to the Congressionally-mandated limit of 70,000 metric tons of used nuclear fuel storage capacity at Yucca Mountain, within a decade the U.S. will have generated as much used commercial nuclear fuel as would fill it to its legislated capacity (63,000 metric tons).[15] While studies to date indicate that a repository at Yucca Mountain could accommodate used nuclear fuel well above this limit, substantial growth in nuclear energy will necessitate follow-on repositories or legislatively increasing Yucca Mountain's authorized limits if the once-through fuel cycle remains the only option.

- ***Recycle*** - Used nuclear fuel can be chemically processed so that residual fissile materials can be reclaimed and used as feedstock for refabricating fresh nuclear fuel. When used in specially-designed fast reactors, the recycled fuel, which contains significant quantities of plutonium, uranium, and other transuranics that can be consumed in

15 The Congressionally mandated limit of 70,000 metric tons includes 63,000 metric tons of used commercial fuel and 7,000 metric tons of used fuel from the DOD/DOE reactors.

these reactors. Variations on the design can greatly extend nuclear fuel resources. Researchers are investigating the removal and transmutation of long-lived radioactive isotopes from used nuclear fuel, which, if successfully applied cost-effectively on a large scale, would reduce the long-term volume and toxicity of the waste.

From a policy perspective, the main obstacles to reprocessing and recycling are cost and the fact that the separation of plutonium raises concerns about proliferation of nuclear material that may be suitable for use in nuclear weapons. Obtaining fuel from reprocessing is more expensive than from natural uranium today. DOE is conducting research and development to address these concerns. Treatment, recycling and transmutation cannot completely eliminate the hazardous character of the remaining content of the material. As a result, long-term geologic waste isolation is still necessary.

These technologies are now part of a broader DOE initiative, the Global Nuclear Energy Partnership (GNEP), which also proposes a fresh fuel supply and spent fuel take-back regime for user nations that do not develop enrichment and reprocessing facilities of their own. Proponents believe this concept and related institutional initiatives could strengthen national and international non-proliferation regimes to enable increased global reliance upon nuclear energy in future energy plans.

When using either of the above options, there are alternatives to simply disposing of used nuclear fuel or the high level waste from recycling in a geologic repository that can provide additional benefits. These include:

- ***Monitored Retrievable Storage (MRS)***[16] – In the short term, used nuclear fuel can be stored at centralized sites using existing, dry-cask storage technology. This is not a permanent solution, but allows additional time for radioactive decay and the release of heat so that when the fuel is finally deposited into a repository site, the containers can be stored closer together, thereby increasing repository capacity. This option also opens the opportunity for future generations to make use of the energy content in used nuclear fuel.

- ***In-Repository Monitored Retrievable Storage***[17] – This option allows the same flexibility as MRS. However, it offers greater levels of protection than surface storage of used nuclear fuel and allows greater concentrations of fuel to be stored centrally instead of at multiple sites. The facility can be ventilated to remove decay heat, permitting more closely-spaced waste packages. Spent fuel can then be retrieved and treated if necessary. Later, this MRS could be transitioned into a permanent repository. This approach captures the evolution of the design for the Yucca Mountain repository over the last 15 years from a rapid-closure-of-the-repository design to a repository that increasingly appears to be an in-repository monitored retrievable storage facility. Existing legislation stipulates that Yucca Mountain must be approved as a repository before it can be considered as an in-repository MRS facility.[18]

While the current practice of temporarily storing commercial used nuclear fuel at nuclear power plant sites is being done safely, at present only one geologic repository is being considered to handle accumulated wastes from facilities. If new nuclear facilities are built, such an expansion could eventually overwhelm the capacity of the Yucca Mountain repository, even if its capacity limit is extended. Since Congress directed the geologic disposal option, development of the repository at Yucca Mountain is important to some investors as an enabling condition for a major expansion of nuclear energy. Additionally, in some States, such as California, policymakers have enacted a moratorium on construction on new nuclear facilities until a satisfactory fuel storage solution is in place. Ensuring that methods for the management of used nuclear fuel are efficient and effective will be a priority for the industry and State regulators in order to move forward.

The option to use Yucca Mountain as an In-Repository Monitored Retrievable Storage Facility is based on the following factors:

- It provides the time to develop recycling technologies and reasonably determine if used nuclear fuel should be directly disposed of or recycled.

- Like a repository, it would be intended to minimize commitments by future generations for disposal of used nuclear fuel. Repository closure is a relatively low-cost activity.

- Underground facilities provide the greatest public protection against accidents and terrorism. This is a strong near-term driver to get approval of an

16 The terms "monitored retrievable storage" in this context connote extended monitoring and retrievability of the used fuel, not the specific "Monitored Retrievable Storage" system referred to in the Nuclear Waste Policy Act of 1982.

17 See note above.

18 The 1982 Nuclear Waste Policy Act prohibits the siting of an MRS facility in a host State while a permanent repository in the host State is being licensed.

operating facility and provides further support for the use of an underground Monitored Retrievable Storage facility rather than surface storage.

- The phased operation of Yucca Mountain as an MRS facility, first, before transitioning to a permanent repository allows time to better understand the performance of the facility as a repository before making a commitment to close the facility. That understanding should provide more confidence in the safety of the facility after repository closure. If unforeseen problems are identified, recovery and repackaging of used nuclear fuel is simplified. In addition, the phased operation of Yucca Mountain may improve public acceptance and lower costs.

The current licensing process for Yucca Mountain by the U.S. Nuclear Regulatory Commission involves approvals at three stages: (1) license to construct; (2) amendment to "receive and possess" (load): and, much later, (3) amendment to close the repository. This last step could occur many decades after loading. The NRC will want to see more long-term experimental evidence before making a decision for final repository closure. There is a fundamental difference between operating a repository and closing a repository. The proposed policy change may involve small technical changes in the Yucca Mountain repository design but would provide a more credible, adaptable, and more acceptable used nuclear fuel management strategy. The volume of spent nuclear fuel is low compared to the energy it can provide and limited interim storage is a mechanism to allow time for research into more robust solutions.

Current-technology recycling does not avoid the need for a repository or repositories for used nuclear fuel since the process only eliminates a portion of the waste. Even advanced recycling technologies, which would allow for the consumption of long-lived radioactive isotopes, will produce wastes that will require long-term isolation from the environment. If nuclear energy is to play an increased role in the nation's long-term energy future, the benefits of recycling will have to be demonstrated and concerns will have to be resolved. Therefore, conducting the necessary research, so that the U.S. is prepared to adjust its policies and move forward with reprocessing when needed, should be a priority for the U.S. government in balance with other nuclear R&D priorities.

Proliferation of nuclear materials is a potential concern to all Americans. These concerns, broadly, involve the potential for diversion of nuclear materials, diffusion or leakage of sensitive technologies, undeclared fuel cycle facilities, and breakout or withdrawal from the Non-Proliferation Treaty. With the events of September 11, 2001, the focus of non-proliferation efforts has expanded from the spread of nuclear weapons to the nuclear threats posed by terrorists. Although primarily a defense issue related to nuclear weapons, there are indirect implications of these non-proliferation efforts to commercial nuclear power. For example, Iran and North Korea have reportedly undertaken weapons activities under the stated goal of developing commercial nuclear power. In 2005, a conference of experts in non-proliferation and nuclear power addressed these concerns and concluded that the civilian nuclear fuel cycle is not the greatest risk to proliferation; instead, inadequately secured nuclear weapons materials and highly enriched uranium at research reactors pose a more significant risk.[19]

Policymakers should recognize that, ultimately, some combination of interim storage, possible recycling, and direct disposal will be required. Although establishing this ultimate spent fuel management system is not an immediate barrier to the continued use of nuclear energy in the U.S., it is incumbent on policymakers to begin working in earnest to research and evaluate methods of reprocessing that could be acceptable on technical, cost, and non-proliferation grounds.

## Nuclear Waste Fund Reform

Utilities generating nuclear energy pay a fee of one-tenth of one cent for each kilowatt-hour of electricity sold by nuclear facilities in order to finance the permanent disposition of nuclear waste. These costs are passed along to consumers in their utility bills. These fees are placed in the general treasury under the Nuclear Waste Fund (the Fund) and then appropriated to DOE to support the planning, construction, and operation of the nuclear waste repository and the related spent nuclear fuel transportation system. However, as a result of changes in Federal budgetary practices embodied in the Budget Reform Act of 1992, receipts from the Nuclear Waste Fund are no longer designated solely for the purposes of the Nuclear Waste Policy Act but are used to pay for discretionary activities of the Federal government. Therefore the used fuel repository program must compete for funding with other non-Nuclear Waste Policy Act activities undertaken by the Federal government.

In short, there is currently no linkage between the Nuclear Waste Fund revenue and appropriations as was the intent of the Nuclear Waste Policy Act which established the Fund. As a result, although the Nuclear Waste Fund increases by approximately $750 million per year, Congress has only made available a fraction of that amount annually to fulfill long-term nuclear storage requirements. Consumers pay substantially into the Nuclear Waste Fund, but receive few, if any, benefits the Fund's fees are intended to finance.

19 *Strengthening the Nuclear Nonproliferation Regime: Focus on Civilian Nuclear Fuel Cycle*, 14th International Security Conference, Sandia National Laboratory, 2005.

## Public Perception of Nuclear Energy and Infrastructure

Public perceptions of nuclear energy have gone through significant swings since the inception of nuclear energy in the 1950s and 1960s. Once seen as the ideal energy source of the future, the nuclear energy industry began with widespread support from the public and policymakers. Cost overruns of new facilities and electric rate increases raised concerns, but generally through the early 1970s the public enjoyed the benefits of nuclear energy and the industry sustained a largely positive image. Support began to wane in the mid-1970s because of increased concerns over the safety of nuclear energy. The result was that interest in building new nuclear power plants diminished and Wall Street's risk avoidance to financing new nuclear power plants increased.

However, a number of factors is leading to a shift in support for nuclear energy, including projections of increased energy demand, increasing concerns over the emissions by traditional fossil fuel plants of pollutants and greenhouse gases and their effect on climate, increasingly tight markets for natural gas resources, and the need to maintain a sustainable supply of affordable, reliable, and carbon-friendly fuels. Specifically:

- The desire to reduce harmful air emissions such as $CO_2$, NOx, SOx, and mercury is leading to a reevaluation of nuclear energy as a means to provide baseload electricity without emitting air pollutants or greenhouse gases.
- While safety will always be an essential criterion for the licensing and operation of nuclear power facilities, public confidence in the safety of nuclear energy has grown since the 1970s because of the industry's steadily improving safety performance.

After the September 11, 2001 terrorist attacks, concern was raised about the potential for such an attack on a nuclear instillation. The U.S. government and the nuclear energy industry maintain that commercial nuclear power installations in the U.S. are among the most secure industrial facilities in the world. Since September 11, the U.S. nuclear energy industry has taken steps to further strengthen security, both physical security and security forces, and has taken other measures to mitigate the vulnerability of nuclear energy facilities.

Similarly, as nuclear power technology continues to spread to other countries, as the operating licenses of new nuclear power plants are extended, and as new reactor designs with improved safety and efficiency characteristics are developed and built, the U.S. has an unparalleled opportunity to play a leadership role in advocating that the highest standards for safety, operational practices, and regulator oversight be adopted worldwide. It is essential that government, industry, and third-party public and private sector organizations provide objective information on safety, used fuel management, and other key concerns, and document ways in which the industry and regulators are addressing those concerns. While it appears that support for nuclear energy is growing, there is yet no hard evidence on how the public will react when the industry undertakes its first new nuclear power plant.

Indeed, the nation could easily face a demand growth rate that taxes its ability to finance, license and build new nuclear power plants. Limitations in the nation's current fabrication, manufacturing, and human infrastructure will become serious challenges for industry and government leadership. Issues of aging workforce discussed in the CECA Forum's infrastructure recommendations apply to the nuclear energy industry, as well. A multi-agency program established by the Federal government would be valuable in addressing the material and human infrastructure needs of the nuclear energy industry.

### CECA Forum Findings on Nuclear Energy

The CECA Forum found that nuclear energy is an important component of the current electric power sector, and has the potential to become a larger part of the nation's fuels portfolio in the next 20 years and beyond once the barriers are overcome. More specifically, the CECA Forum found that:

- Over the next 20 years, the need will increase for affordable and reliable power that does not emit criteria pollutants and greenhouse gases. Nuclear energy is the only proven resource that can accomplish this goal on a large scale.
- The most significant remaining uncertainties for new nuclear power facilities involve capital cost, the regulatory approval process, and the issue of used or spent fuel management. Beyond these uncertainties lay questions of nuclear fuel cycle proliferation and public perceptions concerning safety.
- Despite efforts of industry, the Federal government, and other nuclear advocates, the development of the Yucca Mountain repository remains controversial. Therefore, it will be important for DOE and the NRC to make near-term progress and complete the licensing process for Yucca Mountain as a used nuclear fuel repository while not compromising safety concerns or public participation in the process.

**Table 6: Opportunities and Barriers for Nuclear Energy**

| Nuclear Energy Opportunities and Barriers | |
|---|---|
| **Opportunities for Greater Utilization of Nuclear Energy** | Increased use of nuclear energy presents an opportunity to provide significant benefits to the stationary energy sector, through:<br>• Increasing capacity of competitive bulk power for growing load centers.<br>• Providing power that produces no emissions of greenhouse gases or criteria pollutants.<br>• Increasing the amount of fuel with low price volatility into the electricity fuels portfolio.<br>• The industry's steady safety performance over the past 25 years improves public confidence in nuclear energy. |
| **Barriers to Greater Utilization of Nuclear Energy** | Barriers to new nuclear facilities fall within the following categories:<br>• Economic competitiveness – under deregulation, nuclear energy must compete on a cost basis with alternatives -- mainly coal, gas, and wind. Long lead times for construction, first-of-kind designs, investor risks, and stringent regulatory requirements can impact its economic viability.<br>• Used fuel management – the lack of a clear, unified used fuel management system for the industry increases concerns for investors and state regulators.<br>• Proliferation risks – the risk of proliferation currently inhibits those options involving a closed nuclear fuel cycle.<br>• Concerns over safety – concerns over the long-term safety of nuclear facilities, from accidents as well as from acts of terror, could be a barrier to approval of new facilities. |

- Of all the options for used nuclear fuel management, an optimal system incorporates a combination of short- and longer-term measures, including direct disposal, interim storage, and eventual recycling once proliferation risks are successfully addressed.
- Although support for nuclear energy appears to be growing, it is essential that the public and policymakers receive clear, impartial, and balanced information so that the risks and benefits of nuclear energy can be assessed based on objective analysis and decisions can be made.

## 3.3 Renewable Energy Resources: Key Policy Issues

Concern over global climate change is one of the key drivers in the decision to deploy renewable energy resources, efficiency, and other non-carbon emitting technologies. A legislated carbon constraint policy would affect the technologies associated with renewable energy. Whatever form future Federal climate policy takes, it is clear that technology development in renewable energy and energy efficiency is critical to achieving a zero or near zero emissions future. Among the most important issues in developing the nation's renewable energy resources are the role of the government in mandating the development of these resources (the Renewable Portfolio Standards debate), research necessary to improve the economics and overall performance, and the integration of renewable energy into the electricity grid.

Renewable energy resources include hydroelectric power, biomass, wind power, solar power, ocean thermal, and geothermal technologies. Renewable energy resource technologies are among the fastest growing segment of the energy sector. Renewable energy resources provide American consumers with clean, domestically available energy. However, until there is greater market penetration of renewables, some of the most promising renewable energy technologies will remain costly. The price of electricity from some renewable energy resources can be among the highest of the energy fuels. In addition, renewable energy is not uniformly available across the nation. Some Regions have more renewable energy potential than others and some Regions have potential for greater diversity among the various renewable energy technologies. Solar power, for example, is best located in the Southwest and other sun-rich areas, while wind power has good locations in the upper Midwest and in offshore locations. Many States have taken an active role in developing their available renewable energy resources with programs tailored to their specific resources and needs.

### *Renewable Energy Resources: Opportunities and Barriers*

#### Renewable Portfolio Standards

One of the most significant public debates concerning the development of renewable energy resources is the question of Renewable Portfolio Standards. An RPS refers to a mandated minimum amount of generated electricity to be derived from renewable sources. Twenty-two States and the District of Columbia currently have some form of an RPS. These mandates differ widely in recognition of the State's needs and resource attributes. Even the definition of what constitutes a renewable energy resource differs, with some States not recognizing hydroelectric power as a renewable energy resource while others include coal waste or efficiency gains from CHP as renewable energy resources. The amount of the renewable mandate also differs, with the more aggressive programs setting renewables at 20 percent of a State's energy portfolio as the goal. Most programs require that the level of renewable energy resources increase over time.

In many States, a central feature of an RPS is the allocation of renewable energy credits (RECs). A credit is a tradable certificate of proof that a unit of electricity (i.e., one kWh) has been generated by an approved renewable energy resource. The credits are the proof that the electricity provider has met its RPS obligations. The tradable aspect of the credit allows generators to decide whether to invest in renewable energy projects and generate their own credits, to enter into long-term contracts to purchase credits or renewable power along with credits, or simply to purchase credits on the spot market.

At this time there is no national RPS requirement. Proponents argue that a mandate is necessary to overcome market barriers. Others argue that such a requirement would add costs to consumers' bills and could result in a transfer of wealth from Regions of the country rich with renewable resources to those with less. To date, it has been the various State governments, together with private partners, that have taken a leadership role in developing renewable resources. State Renewable Portfolio Standards have given States the ability to bring new renewable energy on-line.

## Renewable Energy Resources R&D

As shown in Chapter Four, funding for energy R&D has been decreasing drastically over the past few decades. The majority of renewable energy research programs are not coordinated on a Regional or Federal basis. Without the advancement of "breakthrough technologies" that increase either the efficiency or costs of renewables and other clean energy generation technologies, clean energy technologies will continue to be non-competitive against fossil-fuel based generation and will therefore not be widely deployed through 2025. Yet, based on concerns over the growing impacts of climate change, it is imperative that R&D be undertaken to advance renewable "breakthrough technologies" in the next 20 years and that Congress recognize the need for R&D in renewable energy resources as a major national priority.

A number of States have made substantial investments in R&D for renewable energy technologies, for example, the New York State Energy Research and Development Authority (NYSERDA) and the California Energy Commission (CEC) have active renewable energy technology R&D programs.

However, there are limitations to State leadership in developing these resources, primary of which is the need for research into improvements in technology and their deployment. The benefits of such research extend beyond the individual State lines. The Federal government has served as the primary technology R&D vehicle for renewable energy technologies. Unfortunately, funding for renewable energy R&D has declined substantially since its heyday in the 1970s and Congressional earmarks on that funding have exacerbated the funding situation.

A fund that both assists the States in developing their renewable energy resources and provides for a coordinated large scale research effort is in the national interest. In this report's discussion of fulfilling energy R&D needs, CECA recommends that paying for such a fund given current budget constraints requires exploring alternatives to the conventional appropriation approach. One option could be some form of a Public Benefits Fund, similar to that employed by a number of States, perhaps tied to interstate electricity transmission. Other options may exist as well and need to be explored.

The uneven geographic distribution of renewable resources also dictates the need for increased cooperation to ensure interstate access to energy derived from those renewable resources. States that have renewable mandates should be allowed to count energy brought into the State which was generated in others. This aspect of energy trading also requires coordination on both technical and policy issues to remove barriers, including interconnection standards. Regional bodies such as Regional Transmission Organizations (RTOs) or Independent System Operators (ISOs) where they exist may be in a good position to support such coordination efforts.

## Hydropower Resources

Hydroelectric power represents a unique renewable energy resource opportunity. In a number of States that have developed an RPS program, this resource is not included and some other States only recognize energy derived from small scale projects. There is a significant potential for increased hydroelectric power in this country, and the U.S. Department of Energy has continued to evaluate potential growth in the hydrogen sector since 1998. According to a 1998 study conducted by DOE, 21,000 MW of new hydropower capacity is available at current hydropower projects and non-hydropower dams. DOE is also studying new in-stream and ocean energy technologies. The California Energy Commission's recently approved Integrated Energy Policy Report (November 2005) also recognizes new technologies and applications, such as in-conduit hydropower (turbines installed in pipelines, canals, and aqueducts), and hydropower's ability to complement intermittent sources of energy, such as wind energy.[20]

20 "2005 Integrated Energy Policy Report," California Energy Commission, November 2005, CEC-100-2005-007-CMF.PDF, p. 145–149, 153–154

A January 2006 study by DOE's Idaho National Laboratory reports that 30,000 MW of potential hydropower remains untapped in the U.S. in the form of small hydropower, hydrokinetic and hydropower at non-hydropower dams. In fact, the DOE has reported that hydropower could double its current contribution. In addition, 21,000 MW of new hydropower capacity is available at current hydropower projects and non-hydropower dams.[21] Of this amount, 4,300 MW of additional power can be achieved through efficiency improvements and upgrades at existing projects, and 16,700 MW of power is available by adding hydropower projects at existing non-hydropower dams. CECA believes that incentive provisions within the Energy Policy Act of 2005 should be fully funded to support the realization of this new capacity.

The hydropower industry is primed for responsible growth. There are important opportunities available to expand the nation's hydropower base while providing responsible environmental stewardship. Hydropower potential can be realized with new technologies and efficiency improvements without the construction of new dams. CECA believes that the government should encourage the development of small hydropower projects and the implementation of emerging hydropower technologies. Hydropower continues to develop in new areas, such as in-stream applications and wave technologies. For example, a demonstration project in the East River in New York is looking at in-stream applications of turbines.[22] Another example is a wave hydropower project off the coast of Douglas County, Oregon.[23] With Federal and State incentives, the Electric Power Research Institute (EPRI) predicts that 120 MW of wave hydropower energy could be installed in Oregon, California, and Hawaii by 2010.[24]

Financial and regulatory challenges present significant barriers to development for both traditional and emerging hydropower technologies. Challenges to development of these new hydropower technologies include high capital costs, lack of financial incentives, difficulty in obtaining financing, and transactional costs. In general, small hydropower projects pay the most in process costs because the relative scale of those costs is the same regardless of project size. In the case of emerging technologies, increased experience will provide a needed database to assess environmental and economic impacts. This information, in turn, will facilitate continued improvements in new hydropower technologies. Federal and State cooperation to support the development of hydropower projects that meet regulatory standards will enhance hydropower's role in the nation's future fuels portfolio.

Congress recognized the opportunities available in hydroelectric power and included provisions in the Energy Policy Act of 2005 to encourage hydropower investments with Section 45 production tax credits, an incentive payment program, inclusion of incremental hydropower in the Federal power purchase program, and a Congressional commitment to hydropower research and development programs. However, as with other energy tax credits, these also are limited in application, while budgetary constraints are preventing funding for research into this as well as other renewable technologies.

## Integration and Interconnection of Renewable Energy Resources into Regional Electric Grids

Renewable generation often has characteristics that complicate its integration into transmission grids. These characteristics include both the pattern with which the resources provide power (often intermittently, away from the peak, or otherwise not controllable) and the placement and scale of these resources (often smaller or more remote). Balancing electrical load with generation in real time is a complex challenge. Utility operators often point to the intermittency of wind or solar as a problem for the safety and reliability of the grid, particularly when they approach 20 percent of the resource mix. In addition, some of the most favorable sites for renewable resources, such as wind, for example, are in remote locations that require long range transmission lines, which can be expensive and are difficult to fund. Utility-scale solar facilities are also planned for remote sun-rich desert areas and may have the same transmission barriers.

Policy changes as a result of passage of the Energy Policy Act of 2005 on cost recovery for transmission investments may remedy some of the problem. Nonetheless, the current FERC interconnection rules can be improved so that the interconnection of some renewable energy resources which are small or are in remote locations can be facilitated. This will allow consumers in all Regions of the nation to benefit from the renewable energy technologies in cases in which it is clear that the shared costs of such interconnection will benefit ratepayers.

21 "U.S. Hydropower Resource Assessment Final Report," U.S. Department of Energy, DOE/ID-10430.2, December 1998 and "Hydropower: Setting a Course for Our Energy Future," U.S. Department of Energy, DOE/GO-102004-1981, July 200

22 Electric Power Research Institute (EPRI): White Paper submitted to the Western Governors Association Clean and Diversified Energy Advisory Committee: "Ocean Wave Energy Conversion Technology," Roger Bedard, Ocean Energy Leader, EPRI, and Des McGinnis, Ocean Power Delivery, Ltd., December 15, 2005. See also http://www.verdantpower.com/ and "New York City's Verdant Power of New York, LLC, a kinetic hydropower company, to begin supplying Long Island City with electricity through river turbines, *New York Times*, March 2005. For more information from EPRI, see http://www.epri.com/targetWhitePaperContent.asp?program=267825&value=04T084.0&objid=297213.

23 Oregon Department of Energy, Oregon State University, and Electric Power Research Institute (EPRI): "Seeking Public Support for the Wave Energy Power Plant Offshore Douglas County, Oregon," May 1, 2005. See also http://wave.oregonstate.edu/ and http://www.oceancommission.gov/documents/full_color_rpt/24_chapter24.pdf.

24 EPRI, "Ocean Wave Energy Conversion Technology," 2005.

Electric utilities must meet widely varying loads that change each day and from minute to minute. Most utilities provide electricity from a mixture of generating resources, some of which can follow the load up and down, and some of which cannot. Hydroelectric power, geothermal, and biomass are all dispatchable and capable of meeting load profiles of utilities. Wind and solar, on the other hand, present the challenge for utilities of matching loads when the actual power output is harder to predict. A number of studies have looked at the costs of integrating larger amounts of intermittent resources into specific utility portfolios. The costs come from the additional operation of other generators to control the system and follow load. Studies have found widely differing costs, depending on a region's resource portfolio and level of renewable resource penetration. These costs are likely to grow as more utility-scale wind and solar power is added to the grid.

The integration of renewable energy is further complicated by the retirement of conventional gas-fired units and the growing percentage of combined cycle gas turbine units which have less ability to help with system operation and control. Additionally, in some areas the responsibility for assuring adequate resources and system control services is diffuse or unassigned. Finally, it should be recognized that some forms of renewable power and demand-reducing technologies may actually be part of the solution to the increased need for system control. Examples include:

- Demand response programs that use peak prices to signal consumers to decrease their load will help reduce the need for load following resources.
- Pumped storage hydroelectric plants, especially located near intermittent renewable resources, can provide additional operational control to the system.
- Biodiesel-driven internal combustion or micro-turbine generators, while currently expensive, have the ability to follow load.
- Utility scale advanced battery storage installed near intermittent renewable resources allows for dispatchability.

Renewable generators sited far from load centers face an additional regulatory barrier. The responsibility for the investment in the last parts of the transmission interconnection (the "trunk lines" and the "gen-ties") resides with the generator. Trunk lines are the transmission lines that are built chiefly for the purpose of connecting a group of remote renewable resources to the grid. Gen-ties tie the generator into the network or the trunk line. A trunk line investment is typically much too expensive for a single small generator to support. Thus, a system is needed to either share the trunk-line investment among the co-located renewable generators, or to have the transmission owner or purchasing utilities support part of the investment, assuming that the trunk-line investment is of benefit to the overall system. FERC's rules do not allow for trunk line investments by non-generators, but at least one State, California, has developed alternative mechanisms that can provide for cost recovery by non-generators when it is needed and appropriate to provide public benefits.[25]

Where renewable energy resources are small or located in remote areas, regulators face the difficult problems of both trying to decide what is the economically optimal mix of renewable generation that should be supported by transmission investment and how to develop a mechanism by which additional transmission facilities could be built and paid for. Who should bear the risks of this development, and how can these risks be mitigated? And how large a region should be scanned to analyze the optimal mix of renewable energy and transmission investment?

Recognizing that many of the integration and interconnection challenges for renewable energy resources are region-specific, there are policy actions that should be considered to improve renewable energy integration and increase the amount of transmission investment designed to interconnect remote renewable energy resources, particularly wind and solar power, to the grid.

The challenge of incorporating intermittent resources into the electric power delivery system is currently addressed in several ways. To the extent there are operational challenges, the increased use of cycling fossil plants, pumped hydroelectric facilities, price responsive demand-reducing programs, and distributed generation at load centers can be used. Many of these options could be improved by more nationally-funded research, targeting for example: better-cycling fossil-fired power plants, advanced storage technologies, controllable DG, and other smart grid tools.[26] Additionally, interconnection to a regional grid from a broad portfolio of resources which incorporates wind and solar power, such that the intermittent nature of any of the resources in the portfolio is balanced by the broader pool of resources, is in itself a tool to address integration.

The "chicken and egg" problem of funding transmission interconnection for renewable energy resources can be solved by finding new mechanisms to support investment in transmission for remote and clustered renewable resources.[27]

25 See California's Public Utilities Code, § 399.25.

26 Marty Hoffert, *Renewable Energy Options –An Overview*, from the workshop proceeding "The 10-50 Solution: Technologies and Policies for a Low-Carbon Future," The Pew Center on Global Climate Change and the National Commission on Energy Policy.

27 Clustered renewable resources are those renewable technologies, such as wind farms and multiple solar panels, that are located close to one another for economy of scale purposes. These installations are generally found in remote locations often away from transmission lines.

Two potential approaches, neither of which necessarily precludes the other, are:

- Changes to FERC authority to allow cost recovery by investors in the transmission system for additional facilities not currently covered under existing law, such as trunk lines used to interconnect remote or clustered renewables into the grid.[28] Alternatively, States could develop complementary mechanisms such as California's methodology to allow utility support for trunk line investments.

- The expansion of the nation's Regional transmission systems, including the extension of such a backbone system that encourages significant development of renewable energy resources. Once the cost and scope of the expansion of the Regional transmission backbone are identified, funding by appropriate entities could include cost formulations which would be based on the economic, societal and environmental benefits that such transmission backbone would produce to support deployment of renewable energy resources and, indeed, for all fuels used to generate electricity.[29]

FERC and State and Regional governmental bodies should consider encouraging investment in additional transmission capacity to incorporate renewable energy resources, including renewable technologies that are often difficult to site and interconnect. This analysis should include review of the appropriate funding levels, cost allocation, and cost recovery mechanisms to ensure such additions appropriately balance costs and benefits. Further, Congress should consider expanding FERC's authority to do so under the Federal Power Act, or States and Regions could develop alternative methods to support beneficial transmission investments.

### CECA Forum Findings on Renewable Energy Resources

The CECA Forum recognized that renewable energy resources are among the fastest growing segment of the fuels portfolio. They are currently, however, a small part of the overall stationary energy portfolio and, even at their current growth rate, the percentage of renewable energy resources in the portfolio by 2025 will still be relatively small compared to projections for fossil fuels and nuclear energy. However, the CECA Forum found that opportunities for new developments in renewable energy resource technologies are positive for the nation because of the economic, national security, and climate-friendly nature of renewable energy resources. More specifically, the CECA Forum found that:

- States can play a key role in developing their renewable energy resources that match their specific needs, thereby complementing Federal government support. However, even with States taking the lead on renewable energy policies, the Federal government must provide adequate financing for research and development of emerging renewable energy resource technologies.

- Research and development for promising renewable energy technologies is essential to maintaining the growth and progress renewable energy resource technologies have made in the past decade.

- Renewable energy resources are an important tool for meeting stationary energy needs in accordance with the National Consumer Priority of environmental responsibility. Renewable energy technologies will also become an increasingly important resource for addressing climate change.

- Adding substantial renewable energy resources to the nation's electricity grid will require overcoming challenges in transmitting the power from remote locations and interconnecting intermittent renewable resources, such as wind and solar power, to the national transmission system without compromising the integrity of the grid.

- Increased emphasis on energy storage methods and associated technologies will strengthen the role of intermittent renewable energy resources in the electricity sector.

- Renewable Portfolio Standards continue to be successfully developed and managed at the State level.

- The hydropower industry is primed for responsible growth. There are important opportunities available to expand the nation's hydropower base while providing responsible environmental stewardship.

## 3.4 Energy Efficiency: Key Policy Issues

The concept of energy efficiency encompasses a variety of programs, codes, requirements and energy use behavior patterns. Consumers – from large industrial consumers to residential consumers -- have benefited greatly in the last few decades by implementing energy efficiency programs

28 If needed, Congress could expand FERC's authority to allow this type of investment and cost recovery if the costs and benefits to consumers have been carefully considered through a transparent stakeholder process.

29 One possible forum to discuss this investment might be DOE's investigation to implement Section 368 of the Energy Policy Act of 2005 to designate energy corridors (including electric transmission) on federal land in the 11 Western States. DOE and the Bureau of Land Management are currently holding scoping meetings on this issue. Another potential mechanism would be to utilize the DOE Power Marketing Administration's transmission system as the core of a backbone system.

**Table 7: Opportunities and Barriers for Renewable Energy Resources|**

| DG/CHP Opportunities and Barriers | |
|---|---|
| **Opportunities for Greater Utilization of Renewable Energy Resources** | • Increased use of the broad portfolio of renewable energy resources allows for a larger level of clean, climate-friendly electricity within the nation's resource mix.<br>• Developing innovative technologies to help capture wind power, solar power, geothermal, and hydropower will help keep fuel costs down.<br>• Solutions to integrating renewables into the transmission system will help strengthen the overall transmission backbone.<br>• Development of new technologies increases the opportunity of finding "breakthrough" resources that can have long-lasting positive impacts on the energy infrastructure. |
| **Barriers to Greater Utilization of Renewable Energy Resources** | • Many of the most promising new renewable energy resource technologies still face economic challenges.<br>• Adequate funding from the public, private, and academic sectors for R&D lag behind what is necessary to achieve rapid advancements in new technology development.<br>• Some of the most appropriate sites for utility-scale wind and solar power are in remote regions, making it difficult to connect the power to the national transmission network.<br>• Interconnection of large-scale intermittent resources creates challenges for utilities, transmission companies, and regulators. |

that have resulted in lower end-use costs, higher reliability rates, reduced use of finite fossil fuels, and consequent reductions in greenhouse gas emissions and other pollutants. It is therefore critical that policymakers promote energy efficiency programs as a primary vehicle for optimizing the nation's fuels portfolio over the next 20 years.

## *Energy Efficiency: Opportunities and Barriers*

### *Opportunities*

There are a number of opportunities for promoting greater energy efficiency, including appliance efficiency standards, building codes, voluntary efficiency programs, energy efficiency resource standards, use of third party administrators, programs which decouple utility revenues from energy sales, utility portfolio management, and research and development programs. Many States have moved ahead of the Federal government in promoting energy efficiency measures and much can be learned from these State efforts. California, Vermont and Iowa are examples of States which have taken progressive steps to incorporate effectively energy efficiency programs into their overall State energy resource plans. National attention should be focused on promoting energy efficiency measures, generation and delivery systems, and market structures that reward energy efficiency. Each of these mechanisms for increasing efficiency's role in a diversified fuels portfolio is described in more detail below.

#### Appliance Standards

One of the most successful energy policies in U.S. history, standards have already saved energy users over $50 billion, and are estimated to save almost $200 billion through 2030. Appliance standards will reduce electricity usage by eight percent and peak demand by 13 percent in 2020. The 16 new appliance standards in the Energy Policy Act of 2005 will offset an additional three percent of electric demand growth in 2020. Moreover, appliance standards have evolved into a consensus-based policy process, with regular and productive consultation among stakeholders, which is likely to continue to produce advances in coming years.

#### Building Energy Codes

Building energy codes are a major reason for the substantial drop in heating and cooling energy use per square foot in residential buildings in recent decades. About half the States have adopted modern energy codes for new and renovated buildings. Yet, because building energy codes continue to be a State and local issue, adoption and enforcement of building energy codes remains very uneven across the U.S. The only national attempt at uniform energy codes for buildings, the Building Energy Performance Standards or BEPS program, was repealed during the Reagan Administration. However, the International Code Council (ICC) maintains the International Energy Conservation Code (IECC), which States are mandated to consider for adoption under the Energy Policy Act of 1992. A key policy priority is to create additional funding to help States adopt and enforce the IECC.

#### Voluntary Efficiency Programs

Voluntary efficiency programs complement such regulatory policies as building energy codes and appliance standards by setting energy performance levels above the regulatory minimums, and by offering incentives, technical assistance, and promotion support for market adoption of these advanced technologies. The current Federal umbrella for these efforts is the Energy Star® programs operated by EPA and DOE.

Many States also operate voluntary efficiency programs, often in concert with the Energy Star® brand. In recent years these have been funded primarily through public benefits funds, which typically collect small charges (in the range of 1-3 mils per kWh) on utility bills. In the 1980s and 1990s, efficiency programs were more typically operated as utility-funded Demand Side Management (DSM) programs. A few States still operate regulated DSM programs, while about 20 States operate public benefits programs. Total spending in the States for voluntary efficiency programs is about $1.3 billion. The Energy Star® programs total about $55 million in Federal spending. A national public benefits fund to support State efforts has been proposed in previous Congresses.

### Energy Efficiency Resource Standards (EERS)

Several States, including Texas, Illinois, Connecticut, Nevada, New Jersey, and California, have recently created specific energy savings targets for utilities as a percentage of forecast load growth or as a percentage of total sales. Creating specific energy savings targets represents a departure from the recent public benefits model, in which program targets have been driven primarily by spending levels (e.g., mils per kWh). The EERS approach sets performance targets and charges program operators with designing the most cost-effective programs to reach those targets. In many cases the EERS targets are set based on detailed analysis of program performance and cost-effectiveness, ensuring that the targets are achievable and economically desirable. A national EERS was discussed in the development of the Senate version of the Energy Policy Act of 2005; however, the final Act contains a DOE study provision and a provision authorizing a pilot program to assist five or more States to test this approach.

### Use of Third-Party Administrators

Some States have removed the responsibility for energy efficiency programs from the utilities whose revenues depend on the volume of energy sold. States such as Vermont have authorized a third-party "utility" whose funds come from a public benefits charge collected by the utilities and used by the third party to fund energy efficiency programs.

### Decoupling Utility Revenues From Electricity Throughput

Decoupling utility revenues from throughput means designing ratemaking mechanisms in which a utility's costs are recoverable, even though sales volume is reduced because of efficiency measures or other demand-side programs. Such measures can entail a wide range of performance-based ratemaking options, but the key element for efficiency is to remove the link between revenues and sales, so that sales decrements from efficiency do not affect revenues or profits. California has had such a mechanism in place for decades, and Oregon recently entered a similar tariff arrangement with Northwest Natural, a natural gas company headquartered in Portland.

### Utility Portfolio Management

For the approximately 25 States with restructured electricity markets, distribution utilities are acting as default generation suppliers for the majority of customers. In this environment, energy efficiency should be viewed as part of the distribution company's resource portfolio. In conducting procurements for default generation service and in other respects, distribution utilities can be asked to procure efficiency and renewable energy as part of a diverse and balanced resource portfolio. This approach dovetails well with the EERS approach described above.

### Research and Development

For the medium and long-term timeframe, the "pipeline" needed to ensure an adequate supply of new energy efficiency technology is a robust, diverse, and growing R&D program. Unfortunately, energy efficiency R&D funding has fallen substantially. The Bush Administration's FY 2007 energy efficiency funding request represents a 25 percent drop in R&D funding from 2002 levels — 35 percent after inflation. This shortfall is not being made up by private sector R&D. In fact, energy efficiency funding has virtually disappeared at both the Electric Power Research Institute and the Gas Technology Institute. The Energy Policy Act of 2005 authorizes increases in efficiency funding that are more than double current levels; the President's Council of Advisors on Science and Technology (PCAST), when they last examined this issue, also recommended doubling energy efficiency R&D.

## *Barriers*

Although energy efficiency investments are often highly profitable, a range of obstacles prevents them from being adopted. This appears to be paradoxical, as economics would dictate that rational actors will invest resources to achieve savings where they are cost effective. In practice, however, markets present an array of barriers which results in suppressing energy efficiency below optimal levels. The CECA Forum examined the following barriers and subsequently developed policy options to overcome the barriers:

### Principal-Agent Barriers

Also called the "split-incentive" barrier, this type of barrier occurs when one party (the "agent") does not act in the best interest of another party (the "principal"). A common example includes home builders (agents) failing to invest in the level of energy efficiency that home buyers (principals) would invest in if they had the needed information and capital.

## Transaction Cost Barriers

Energy efficiency tends to occur in small increments, as investments in new homes, new appliances, lighting systems, and the like. It involves millions of individual transactions scattered across multiple sectors of the economy. The costs of gathering needed information, obtaining financing and otherwise facilitating these transactions routinely create barriers to efficiency investment. By contrast, energy supply investments tend to come in fewer and larger increments.

## External Costs

"Externalities" are frequently used to describe the environmental costs associated with energy use. In the past, some States have created "environmental adders" in avoided cost calculations to attempt to "internalize" such costs in electricity prices. However, in today's restructured markets, the concept of externalities can take other forms. For example, in transmission planning, energy efficiency investments are valued only in terms of avoided transmission costs, while the efficiency investment also avoids costs in generation, distribution, and air pollutant and greenhouse gas emissions. Depending on the boundaries of the market involved, many of the benefits of energy efficiency investments remain external to the stream of benefits that the market is able to value.

## Counter-Effects to Demand Elasticity

As incomes rise above a subsistence threshold, discretionary income becomes increasingly available to spend on increased levels of energy services. Rising incomes in recent decades have enabled more and more U.S. households to increase energy use, even in the face of rising energy prices.

## Price Volatility and Transparency

The lack of predictability in future energy prices dampens investment in both energy efficiency and energy supply opportunities. In the 1980s, many contracts signed by energy service companies were abrogated when oil prices dropped. In addition, utility bills as currently structured provide a very muddy price signal to consumers. By contrast, motor fuel prices are posted prominently, with competitors' prices often within the consumer's view, prior to the purchase.

## Bounded Rationality

Behavioral economics has identified a range of cognitive and behavioral phenomena that inhibit fully-rational economic behavior with regard to energy efficiency investments. Consumers display "bounded rationality" in the form of rules-of-thumb or other mental shortcuts in evaluating energy-related purchases that can lead to sub-optimal behavior. Consumers often assume that any new appliance is energy-efficient, compared to the unit being replaced, when in fact there may be a wide range of higher-efficiency choices. Recent behavioral economics studies indicate that many consumers display certain kinds of risk avoidance that keep them from making good investments, despite relatively reliable data documenting the merits of the investment.

## Buying Decision Drivers

Market research has identified a number of key drivers that often work against energy efficiency investment decisions by consumers and business regarding the purchase of energy-consuming products. These include:

- ***Convenience.*** Many energy users simply want energy to be available and are relatively indifferent to prices or changes in energy bills.
- ***Competing attributes.*** Buyers may be more focused on non-energy attributes, such as size, performance, or reliability than on energy use.
- ***Security.*** Many buyers want to be "safe" in their purchasing and so will not try new products, brands or services.
- ***Brand loyalty.*** Some consumers simply choose familiar brands as the basis for buying decisions.

## Organizational Behavior

Organizational investment priorities often downgrade the importance of energy efficiency investments, because the efficiency investment is not seen as central to its mission and strategy, regardless of the stand-alone economic merits of the investment. Given transaction costs and limits to capital, this effect can keep energy efficiency investments chronically stuck on the back burner.

## Linkage of Utility Revenues to Electricity Throughput

Even though distribution utility costs are largely fixed in a given year, revenues are still typically based on volumetric sales. This means that if sales are lower than forecast, revenue is reduced; the converse is true for above-forecast sales. Even though overall returns are nominally regulated, the effect on earnings in a given year can be strongly affected by variations in sales. Some States have decoupled revenues from sales through rate adjustment mechanisms.

**Table 8: Opportunities and Barriers for Energy Efficiency**

| Energy Efficiency Opportunities and Barriers | |
|---|---|
| **Opportunities for Greater Utilization of Energy Efficiency Measures** | Greater use of energy efficiency measures can be accomplished through:<br>• Appliance standards<br>• Building codes<br>• Voluntary efficiency programs<br>• Energy Efficiency Resource Standards (EERS)<br>• Decoupling utility revenues from electricity throughput<br>• Utility portfolio management<br>• Research and development |
| **Barriers to Greater Utilization of Energy Efficiency Measures** | • Cost barriers, including principal-agent conflicts, transaction costs, and externalities, prevent the true economic benefits from being seen.<br>• Purchase barriers, including limited disposable income, lack of transparency to see benefits, and upfront costs, limit decisions that would otherwise have long-term economic benefits.<br>• Mindset barriers, including the perception that efficiency is not a legitimate capital consideration, prevent implementation.<br>• Inverse incentives for regulated utilities that link revenue to electricity throughput. |

## *CECA Forum Findings on Energy Efficiency*

From the perspective of the National Consumer Priorities developed by the CECA Forum, reducing the amount of fuels consumed to meet the nation's energy requirements through energy efficiency measures translates into optimizing each of the National Consumer Priorities with the least cost to consumers. The CECA Forum recognized that efficiency measures can and should play a strong role in meeting stationary energy needs through the 2025 timeframe of the CECA study, and that maximizing these resources will allow the nation to make better use of the diversified fuels portfolio. More specifically, the CECA Forum found that:

- There is substantial room for improvement in using fuels efficiently, and energy efficiency measures can play a considerably larger and more effective role over the next 20 years.

- State building codes are proven to reduce the energy needed for heating and cooling, but adoption and enforcement of energy codes remains very uneven across the U.S. absent national building codes.

- Among the most significant policy directions that can be taken to encourage additional energy efficiency are greater emphasis on appliance efficiency standards, building codes, Energy Efficiency Resource Standards (EERS).

- Decoupling utility revenues from throughput is one option for reversing the disincentive for utilities to encourage energy efficiency measures. Regulated States have other options available that can have equal results.

# CHAPTER FOUR:

# Key Cross-Cutting Policy Issues With CECA Forum Findings

## 4.0 Key Cross-Cutting Policy Issues

In addition to examining specific fuels and related technologies in Chapter Three, the CECA Forum identified a series of primary overarching issues that will impact all fuels and technologies through the 2025 timeframe of this study. This chapter is devoted to those overarching issues and includes a discussion of the following:

- ***Research and development programs*** to ensure that the nation's energy needs are met in ways that optimize the benefits of all fuels. These R&D programs cut across all fuels and all technologies. The growing demand for energy must be met in a manner consistent with the National Consumer Priorities of affordability, environmental responsibility, reliability, safety, and security. To accomplish these goals, the importance of energy R&D is explored.

- ***Upgrading the nation's energy infrastructure*** to accommodate the expected growth in energy demand. Upgrading the infrastructure requires ensuring a healthy fuels transportation system; modernizing the nation's electric transmission system; ensuring the skilled workforce required to design, build, and operate complex energy systems; and protecting the infrastructure against vulnerability. Many aspects of energy systems infrastructure are discussed to guide future policy.

- ***Interdependence of energy system needs and water availability*** promises to be one of the most far-reaching and least recognized issues affecting the ability to provide reliable power through the 2025 timeframe of the CECA study. Energy production uses more water than all other industries and is comparable to agriculture's use of water. Severe shortages of water will have dire consequences on energy systems. The CECA Forum examined these critical interdependencies.

- ***Issues relating to the nation's future carbon policy*** affect all fuels and technologies. Technologies and policies are examined to steer the nation on a path to reducing carbon intensity and greenhouse gas emissions. The goal is to ensure that future energy needs are met in ways that are environmentally responsible and that future generations inherit a sustainable planet.

The CECA Forum also addressed the role of government in ensuring that consumers receive the social, economic, and environmental benefits they expect from the energy system. Government policies stimulate research, development, and deployment of new breakthrough technologies that bring down the high capital costs of clean energy technologies and make them economically competitive. Government establishes regulatory structures and market rules to protect consumers and it is charged with the power to impose penalties to ensure compliance.

Although the role of government in energy markets has changed substantially over the past several decades, as discussed more fully in the history of energy policy in Chapter Seven, the optimal role of government, particularly the Federal government, continues to evolve. The reality of operating the nation's energy infrastructure and associated markets may require government intervention to address market imperfections needed to protect consumers. A properly functioning energy market would be one in which barriers to entry do not exist. Energy markets, however, are replete with barriers to entry, which range from the high cost of energy infrastructure, economies of scale which enable existing players to sell at a lower cost than new entrants, and single proprietorship of resources ranging from critical infrastructure to hydrocarbon deposits. Subsidies, such as production tax credits, are one means of lowering barriers to entry. Special regulations, such as open-access transmission tariffs to stimulate competition in electric generation, as well as Renewable Portfolio Standards to provide incentives to the development of renewable resources, are other means.

High transaction costs also dominate energy investments. Building new facilities, such as pipelines, transmission lines, LNG ports, oil fields, or power plants, is typically a long, expensive, and litigious process. Newer technologies, such as fuel cells and distributed energy resources, can provide significant benefits to consumers but they also face high transaction costs in the form of research or feasibility studies to determine the impact of these resources on the grid. Utility engineers sometimes have little experience with new technologies and are hesitant to deploy them without a proven track record; electrical and gas inspectors may not have sufficient information to approve them; and insurance companies may have little actuarial data to support affordable policies for renewable generators. As a result, projects that would otherwise be economically viable may not be undertaken. Government can work with industry to develop public/private partnerships to fund these critical energy investments.

The issue of whether and to what extent government should develop policy responses is important in energy policy debates. To maximize the effectiveness of energy policy decisions with the least impact on consumers, the following principles should be applied:

- *National Consumer Priorities* – Government policies regarding fuels and technologies should be designed to support the National Consumer Priorities developed by the CECA Forum. The criteria of environmental protection, affordable and predictable energy services, reliable and high quality energy services, public safety, and system security should be taken into account whenever policy decisions are being made.
- *Alleviate Market Failures* – Government policies should be used to address market failures, such as high barriers to entry, high transaction costs, and substantial externalities.
- *Ensure Consistency* – Government subsidies, tax credits, and market rules affect investment decisions and should be applied with consistency. Inconsistent application of these measures can increase investment risk and stymie development of the desired resources.
- *Harmonize with Other Policies* – Policies among and within agencies should be coordinated to avoid conflicts and unintended consequences.
- *Equitably Share Costs* – The costs of policies should be shared equitably.

Government can also play a valuable role in informing the public about factors driving energy policy decisions. With energy as a key economic driver, an enlightened citizenry is essential to the government's ability to develop energy policies in the public interest. In addition to serving the energy needs of the United States, government can play a leadership role in bringing clean energy technologies, technical expertise and best practices to developing nations.

## 4.1 Coordination and Funding of Research and Development Efforts

Affordable clean energy technologies[1] will be the backbone of any national or international attempt to reduce greenhouse gas emissions significantly. Without "breakthrough technologies"[2] affecting either the efficiency or costs, clean energy technologies will not be widely deployed.

The research pipeline starts with basic science and continues to successful deployment. In between are such thrusts as concept development, engineering design, and prototype demonstrations. However, research needs do not end with deployment, as product and process improvements are identified to improve the efficiency, cost, or environmental performance of existing technologies. With regard to public funding for R&D, a key issue is where in the research cycle is the private sector's responsibility for conducting research and what is the appropriate role for government?

Government has a responsibility to address national and economic security concerns associated with energy R&D and deployment of new technologies. The government has a responsibility to intervene when the immense cost and business risk associated with deployment of new environmentally responsible fuel technologies is greater than the private sector can bear and when such technologies are deemed to be in the public interest.

Remarkably, in spite of these needs, since the 1970s public and private funding of R&D for energy technologies has been in steady decline. According to a May 2004 report by Resources for the Future, "Despite its long-term benefits and increasing concerns over global climate change, energy R&D has been decreasing dramatically in both the public and private sectors over the last several decades."[3] This trend is not unique to the U.S. Funding for energy R&D in the European Union as a proportion of total R&D has declined

1 "Clean energy technologies" are defined as technologies that have significantly less $CO_2$ or mercury emissions than pulverized coal-fired power plants. This discussion includes nuclear, IGCC and fuel cells as clean energy technologies.

2 "Breakthrough technologies" are technological innovation to existing technologies that will dramatically reduce the cost and increase the efficiency of current technologies.

3 Jeffery Chow and Richard Newell, "A Retrospective Review of the Performance of Energy R&D," draft discussion paper, Resources for the Future, May 2004.

from a high of approximately 50 percent in the 1980s to a projected 14 percent between 1998 and 2002.[4]

Unfortunately, the existing method of appropriating Federal funds disadvantages energy R&D as other more immediate priorities outweigh R&D needs. For example, although authorization levels for energy R&D rose in the Energy Policy Act of 2005, appropriation requests fell short of meeting authorized levels. Some energy areas such as hydroelectric power research received no funding. In addition, the Federal funding that has been forthcoming has been hampered by Congressional earmarks that often allocate available funding to low priority efforts, leaving little funds remaining for essential research.

There are a variety of models for alternative funding mechanisms in the Federal government and in the States. Each mechanism has strengths and weaknesses. For example, dedicating funding against fees or receipts is the means by which FERC and the NRC operate, while projected revenues from energy sales fund the operation of the Bonneville Power Administration. However, when dedicating a source of funds to fulfill specific needs, there are some less successful examples, most notably the Nuclear Waste Fund discussed in Chapter Three. In the States, much research is conducted with funds collected from charges on utility bills. These funds, known as Public Benefit Funds, require a percentage of the ratepayer's bill to be dedicated to efforts in support of renewable energy resources, energy efficiency, and other public energy benefits. In regulated States, similar costs are often included in the rate base.

Since some of the benefits of today's energy R&D efforts may not be ripe until 2020 or later, government and industry have been engaged in identifying affordable technologies with the greatest potential to improve the performance, cost, and environmental attributes of fuels. Current energy R&D is implemented through a variety of Federal, State, university, and industry programs. Policymakers have acknowledged the need for more coordination in R&D activities and adherence to a strategic focus. DOE has announced a stronger commitment to R&D and, through the Secretary's Office, is attempting to plan for R&D more rigorously. In addition, in an effort to coordinate and improve energy-related R&D efforts, Congress created in the Energy Policy Act of 2005 a new DOE Under Secretary for Science. Congress has also directed the creation of a senior position in DOE to promote technology transfer and commercialization of energy technologies to make the products of the research programs more responsive to the needs of the energy industry and to benefit consumers.

4 PJ Runci, Pacific Northwest National Laboratory for the U.S. Department of Energy, "Energy R&D in the European Union," May 1999.

### CECA Forum Findings on Coordination and Funding of Energy Research and Development

- Government has a responsibility to address national and economic security concerns associated with energy R&D and deployment of new technologies. Yet, since the 1970s public and private funding of R&D for energy technologies has been in steady decline.
- Without breakthrough technologies affecting efficiency or costs, clean energy technologies will not be widely deployed.
- There are a variety of models for alternative funding mechanisms in the Federal government and in the States, including dedicated funding from receipts, projected revenues from energy sales, and Public Benefit Funds. Each mechanism has strengths and weaknesses.
- Funding for essential R&D is hampered by the practice of funding Congressional earmarks.
- Benefits of today's energy R&D efforts may not be realized for decades. Funding for more immediate priorities results in decreased dollars for energy R&D.
- Current energy R&D is implemented through a variety of Federal, State, university, and industry programs. More coordination in R&D activities and adherence to a strategic focus is needed.

## 4.2 Upgrading the Nation's Energy Systems Infrastructure

In planning to meet projected energy demand for 2025, a key consideration is the capability of the energy infrastructure to move that energy from its source to its market. Energy transportation for fuel supply includes rail and barge transportation for coal supplies, two systems which are greatly in need of upgrade. Energy transportation also includes natural gas pipelines, substations, and terminals. If the supply of imported liquefied natural gas grows as a complement to domestic natural gas, investment in the LNG infrastructure to support such imports will be necessary.

Upgrading the nation's energy systems infrastructure also requires modernization of the U.S. transmission system to meet increasing demands on the electric power delivery system. Upgrading the nation's energy infrastructure entails a critical commitment to educate, train, and maintain the skilled workforce capable of designing, building, and operating energy systems so that growing end-use requirements can be met and the U.S. can remain competitive in a global economy. Each of these issues is discussed below.

## Fuel Transportation by Rail and Barge

Rail and barge transportation of fuel supply constitute the number one and two transport means for delivering coal to the electrical generator. Not all new generation is sited in a location served by more than one railroad or on navigable waterways. Currently approximately 30 percent of total coal-generating capacity comes from coal-fired power plants that are served by a single railroad transporter. Some contend this places captive coal users at a significant disadvantage. They say that without competition, coal users are forced to pay monopoly rail rates charged by a single company. They say this is responsible for higher charges for coal and, ultimately, higher delivered electricity costs to consumers. Others counter that rail rates are regulated by the Surface Transportation Board (STB), which has a responsibility to prevent predatory rates from being charged. According to the U.S. Department of Transportation, "rates are not regulated when competition keeps freight rates at levels below the statutory threshold (where the ratio of the revenue to the regulatory variable cost of the move is less that 1.8), when a class of traffic has been specifically exempted, or when traffic moves under contract."[5]

It is clear that captive rail customers pay a higher price for the delivery of coal than do those who are served by multiple rail carriers. Whether this disadvantages the customer is a topic of debate. A higher price paid for shipping is clearly a concern for captive rail customers, but, in some cases, there are compensating factors. For instance, the increase in shipping may be outweighed by a favorable facility location or other workforce, resource, or economic factors. As of 1999, seven of the top 10 lowest-cost coal generation plants were served by only one railroad.[6] Several bills to address the captive shipper issue have been introduced in Congress, but no action has yet been taken.

In 1980, Congress passed the Staggers Rail Act (the Staggers Act) which had the effect of largely deregulating the industry. At the time of the Staggers Act, over 40 Class I railroads competed for business in this industry. Today, four Class I railroads provide 95 percent of the rail business in North America. As a result, entire industries and regions are served by only one railroad. Despite the shrinking of the number of competitive rail providers, national average freight rates have declined by an average of one to two percent per year, adjusted for inflation, since the passage of the Act in 1980.[7] Under the Staggers Act, Congress sought to protect captive customers by providing a "rate reasonableness" review. This review process takes place before the STB, which has exclusive jurisdiction. One aspect of this review of particular note is that the STB applies a "stand-alone cost" (SAC) standard, which requires captive customers to pay the equivalent cost of building and owning their own hypothetical highly efficient railroad. Many contend that the SAC standard is confusing, laborious, and expensive to pursue and that the SAC standard is in dire need of replacement with a new methodology that is fair, reasonable, and timely.

In any event, demand for rail freight is increasing due to the state of the economy and the fuel efficiency of railroads relative to trucking. Railroads must invest significant capital in order to remove bottlenecks and improve throughput to meet this growing demand. It is estimated that freight traffic will grow by more than two-thirds by 2020.[8] Class I Railroads will spend more than $8 billion in 2006 on capital expenditures, a 21 percent increase over 2005.[9] Even more investment will likely be needed to keep pace with the increasing demand. It has been reported that legislation, referred to as the Freight Rail Infrastructure Capacity Expansion Act, will be introduced in Congress soon to provide railroads with investment tax credits for expansion projects.[10]

Beyond rail, barge is the second most significant transportation means for moving fuel, primarily coal supplies. Regulators and industry anticipate that commerce over the nation's waterways will more than double by the year 2025. The American Waterways Operators estimates that barges "safely and efficiently move fully 15 percent of the nation's freight for less than two percent of its total freight bill, saving shippers and consumers more than $7 billion annually compared to alternate transportation modes." Unfortunately, this valuable system of waterways is in dire need of repair and improvement, but Federal monies have not been appropriated and other monies available have not been used.

For now and for the foreseeable future, Congress will need to consider authorizing the U.S. Army Corps of Engineers (the Corps) to upgrade and maintain the system of locks and dams that remain vital for the nation's navigable waterways, the importance of which were highlighted by the disruptions of barge traffic caused by Hurricanes Katrina and Rita in 2005. The primary mechanisms for maintaining adequate water levels on navigable waterways is a system of locks and

5 U.S. Department of Transportation, "Impact of the Staggers Rail Act of 1980," at http://www.fra.dot.gov/downloads/policy/staggers_rail_act_impact.pdf, accessed on March 16, 2006.

6 Association of American Railroads, "Railroads and Coal: Overview," March 2006.

7 U.S. Department of Transportation, "Impact of the Staggers Rail Act of 1980," at http://www.fra.dot.gov/downloads/policy/staggers_rail_act_impact.pdf, accessed on March 16, 2006.

8 *Argus Rail Business*. Volume 12. March 20, 2006 at http://www.argusonline.com.

9 *Ibid.*

10 *Ibid.*

dams operated and maintained by the Corps. The Federal Inland Waterways Trust Fund (Trust Fund) provides partial funding for the construction and rehabilitation costs for locks, dams, and infrastructure development of the nation's waterways. Over $100 million a year in fuel taxes is paid by the barge and towing industry to the Trust Fund. Construction and rehabilitation costs are paid half by the Trust Fund and half by Congressionally appropriated funds. In the recent past the Trust Fund has had a balance of approximately $378 million that has not been spent because Congress failed to appropriate matching funds.

The Water Resources Development Act of 2005 (WRDA), a bill normally passed biannually to address the needs of the nation's waterways, was last passed by Congress in 2000. Although the U.S. House of Representatives passed the bill in July 2005, the U.S. Senate has not acted at the time of publication of this report.

## *Modernizing the Nation's Transmission System*

Modernization of the interstate electric transmission system is needed to facilitate efficient regional delivery of wholesale power and maintain regional reliability. A regional transmission highway system will facilitate efficient wholesale markets, which should reduce price volatility, permit the retirement of older, less environmentally-friendly generation facilities, and improve national security through system redundancy.

The most critical infrastructure investment is the construction and use of the high voltage electric transmission system throughout the nation. Undertaking a project to build and operate a high voltage electric transmission line requires the cooperation and approval of numerous regulators, financial investors, and community participants. Owners and investors make investment decisions based on the risk of a project being completed in a timely manner and operated profitably. One of the greatest risks related to investing in transmission is regulatory uncertainty. This uncertainty includes conflicting Federal and State regulations as well as a lack of appropriate policy mechanisms. Congress has attempted to resolve jurisdictional conflicts in the Electricity Title of the Energy Policy Act of 2005 and DOE, FERC and the States have begun to implement the provisions mandated by the Act.

Transparent and durable regulatory, legislative and financial frameworks are key to motivating transmission owners, operators, and investors to undertake aggressive and economic expansion of transmission facilities. Regulatory policy should be designed to ensure the equitable and timely recovery of costs necessary for low cost financing, appropriate cost assignment (minimizing inappropriate cross subsidies), and tailored incentives for accomplishing the various goals established by regulators. The balance between Federal and State jurisdiction involves States retaining authority over generation resource adequacy and local reliability and FERC exercising authority over regional reliability and market efficiency. The process of regional planning is critical for determining needs and enhancing the transmission grid. The key players – DOE, FERC, RTOs, State utility regulators, and transmission owners – each play an important role in decisions affecting the transmission system. The Energy Policy Act of 2005 addressed some of these issues when it directed DOE to designate national electricity corridors in which Federal backstop transmission siting is applicable. DOE was also designated lead Federal agency for the siting approval process.

In 2005, CECA issued a report on the transmission needs of the nation.[11] That report, *Keeping the Power Flowing: Ensuring a Strong Transmission System to Support Consumer Needs for Cost-Effectiveness, Security, and Reliability*, detailed a number of recommendations to policymakers to ensure consumers have a reliable system of transmitting electricity across the nation. A central concern of *Keeping the Power Flowing* was the recognition that significant investment in upgrading and expanding the transmission system is needed in the next few years to meet increasing consumer demands on the system. CECA advocated the construction of a regional electric transmission system to increase system efficiency and reliability, dampen energy price volatility, and reduce dependence on foreign sources of energy.

## *Liquefied Natural Gas Infrastructure*

As seen in Chapter Three many energy analysts are projecting a need for increased imports of liquefied natural gas to meet future U.S. natural gas demands. Others believe that siting and safety concerns, balance of payments issues, dependence on foreign sources of supply, and security and cost considerations will limit the importation of LNG. If those issues can be resolved and if LNG is to play an important role, significant investments in new LNG terminals, pipelines, and other infrastructure will be required.

At last count, approximately 55 LNG terminals were in various stages of planning, including expansions at the four existing terminals in the U.S. and an additional 12 terminals for Mexico and Canada. Half of the terminals are targeted for the Gulf Coast. About 25 percent are planned for the Northeastern U.S. and Canada.

11 CECA, *Keeping the Power Flowing: Ensuring a Strong Transmission System to Support Consumer Needs for Cost-Effectiveness, Security, and Reliability*, Washington, DC, January 2005.

With a strong demand for gas and a large domestic pipeline infrastructure that provides access to other regions of the U.S., the Gulf Coast has been the area of the largest concentration of LNG infrastructure investments. The Gulf Coasts of Texas and Louisiana have heavy concentrations of petrochemical plants and refineries that use natural gas as a feedstock and for other process uses, as well as gas-fired power generation. In 2002, these States consumed 5.5 tcf of natural gas or 23 percent of the national total. The Gulf Coast benefits from available capacity on the pipeline network, access to other markets, near-by market hubs, and local storage. The decline in U.S. production in the Gulf Coast has created spare pipeline capacity that connects to virtually every pipeline serving the Eastern half of the country. Between South Texas and Alabama, approximately 30 market pricing points (or hubs) are found where 40 percent of all gas consumed in the U.S. is sold. Henry Hub, Louisiana is the national market center where the NYMEX futures contracts are traded. Local high deliverability storage is desirable to LNG importers seeking to provide steady baseload deliveries because storage allows them to better balance cargo deliveries with sales from receiving terminals. However, the heavy concentration of proposed LNG projects in the Gulf Coast raises concerns related to infrastructure vulnerabilities in the aftermath of Hurricanes Katrina and Rita and the direct impact on the prices and supply availability to all regions of the U.S.

It should be noted that Alaska, the third largest producer of natural gas in the U.S., producing some nine Bcfd since 1995, re-injects more than 80 percent of the produced gas due to lack of necessary infrastructure to move the gas to the Lower-48. At issue, therefore, is the need to explore the ramifications of building the Alaska Natural Gas Pipeline or in expanding and/or building new LNG and export infrastructure in Alaska. If the controversies regarding LNG imports, including safety, security, cost, and siting, are resolved, an adequate infrastructure must be built and maintained.

## Maintaining a Skilled Energy Systems Workforce

The workforce required to meet the nation's energy challenges through 2025 is aging and in short supply. The number of students entering engineering and related fields of study necessary to design, construct and operate the nation's complex energy systems is inadequate to meet projected demand. A study by the National Petroleum Council noted, for example, that without quick action, impending shortages of qualified personnel are expected to hinder the ability of the producing sector to find and develop required gas supplies.[12]

The skills shortage is not limited to oil and gas, but permeates the utility sector, in which nearly half of the workforce is over the age of 45.[13] Declines in enrollment in undergraduate petroleum engineering and geosciences' degree programs were 77 and 60 percent, respectively, between 1985 and 1998.[14] While enrollments in nuclear departments have been steadily increasing in recent years, the pace of graduating engineers is still outstripped by the anticipated need.

A 2006 National Academy of Sciences' (NAS) study, *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*, points out that American students continue to fall behind those in other countries in science and engineering degrees. Further, a growing number of students graduating with science and engineering degrees from U.S. universities are foreign-born and are often required to leave the U.S. upon graduation. More troubling is that the drop in the number of science graduates seems to be rooted in the U.S. education system itself. According to the NAS report, students in grade school are not performing at a level that is competitive with students in other countries. Some suggest this is because science is not a pedagogical priority; in 2000, 93 percent of students in grades 5-9 were taught physical sciences by a teacher who neither majored in nor held certification in any of the physical sciences, chemistry, geology, general sciences, or physics.[15]

## Infrastructure Vulnerabilities

The nation's stationary energy infrastructure has evolved into a remarkably complex and interdependent network of pipelines, transmission wires, and multi-fueled generating stations to deliver energy to consumers. It is common for weather modelers to debate whether "the flap of a butterfly's wings in Brazil sets off a tornado in Texas."[16] For energy policymakers and market players, a parallel question is: "What are the impacts of a tornado in Texas on natural gas deliveries to New York City?"

The sequential set of activities that converts energy inputs to value-added outputs results in a complex, interdependent, and potentially vulnerable energy delivery process in which removal of one energy source can jeopardize the proper

12 T. Hess, Apache Corporation, Statement before the House Committee on Resources, Hearing on Aging of the Energy and Minerals Workforce, Washington, DC, July 8, 2004.
13 Katherine Gomm, "The Aging U.S. Workforce and the Utilities Industry," *UTC Research*, March 2004.
14 Hess, op. cit.
15 The National Academies, *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*, Washington, DC, February 2006.
16 Edward Lorenz, "*Predictability: Does the Flap of a Butterfly's Wings in Brazil Set off a Tornado in Texas?"* Speech given at the American Association for the Advancement of Science, Washington, DC, 1972.

functioning of others. Under normal operating conditions the system generally works harmoniously. However, disruptions can occur due to a range of factors. These factors fall into three categories: technical/infrastructure; natural disasters such as extreme weather events and earthquakes; and accidental or deliberate human actions. While each of these categories represents potentially serious concerns for energy system managers, extreme weather is likely to generate the greatest level of concern.

## Technical/Infrastructure Vulnerabilities

Energy systems are highly interdependent and require careful planning to maintain reliability across all energy systems and fuels. Planning for the maintenance of individual components, procurement of fuel supplies, and other routine operational activities must be made with the functional health of the entire system in mind. Additionally, steadily rising energy use against a backdrop of increasing difficulty in siting new facilities and heightened concern over greenhouse gas emissions factor into planning as well. Together, these factors increase the pressure on existing infrastructure, demand that closer attention be paid to its vulnerabilities, and require greater recognition of the interdependencies among energy systems and fuels.

The potential for technical/infrastructure disruptions is strongest in areas where energy systems are undergoing rapid transformation, particularly as regions change their energy mix and consequently their energy delivery networks. The fact that a significant majority of the nation's new generation facilities rely on natural gas as either a primary or secondary fuel makes the natural gas/electricity linkage of particular concern. Also, the fact that such major cities as New York and Boston will rely on natural gas for upwards of 80 percent of their electricity generation by 2010[17] underscores the challenge. Unless substitute fuels are used to replace gas-fired electric generation, failures in the natural gas system may result in substantial electric outages.

Although a major concern is the interdependency of gas and electricity, all fuels and systems are interdependent. The introduction of carbon regulations will drive significant increases in the use of renewable energy resources. Wind power is currently the most economical of the renewable technologies to develop and deploy and would likely account for much of the increase; however, its intermittent nature presents the challenge of meeting consumer demands that do not necessarily coincide with peak wind patterns. The absence of carbon regulations does not necessarily improve the situation. Coal consumption could increase by 20 percent or more through 2025.[18] However, the coal industry is currently contending with an increasingly tight market for rail transportation, raising potential concerns about how a disruption to the transportation market (e.g., a rail strike) would affect the ability of coal power plants to procure sufficient fuel. Partially in response to this issue, coal companies and utilities are showing interest in locating power plants in close proximity to coal mines, thereby reducing concerns over coal transportation. In these instances, electric transmission lines would need to be constructed from the power plant to major transmission grids; hence, this approach is sometimes referred to as "coal by wire."

## Natural Disasters

The energy infrastructure is vulnerable to severe weather events and other natural disasters, such as earthquakes and floods, yet it has historically responded rapidly and effectively to such natural disasters.[19] Nevertheless, extreme weather over the past two years has demonstrated the vulnerability of energy systems to a multitude of forces which cannot be out-engineered.

Hurricanes pose a unique threat to the U.S. energy infrastructure, as most of the U.S. petroleum refining and natural gas operations are located in the Gulf of Mexico region. In 2004, Hurricane Ivan briefly hampered natural gas distribution and oil refining and distribution capabilities when it struck the Florida and Alabama coasts, driving natural gas prices higher throughout the country. However, the impact of Hurricane Katrina in August 2005 has been even more severe. The storm, one of the most powerful recorded storms in U.S. history, directly hit the region's extensive petroleum and natural gas infrastructure precisely at the time fuel prices were already at or near record levels.

Early estimates of the effects of Hurricane Katrina from a vulnerability and interdependency perspective are dramatic. The EIA projected a particularly strong impact on hydropower production, which is forecast to increase by three percent nationally in 2005 and 10 percent in 2006. This is a result of the fact that natural gas was expected to remain above $10 per million cubic feet (mcf) through the 2006 winter heating season, resulting in delivered prices about 50 percent higher than in 2004, which was itself an expensive year.[20] Heating oil prices were anticipated to rise in 2006 between 29 and 31 percent, depending on the length of the recovery time and assuming additional capacity reductions due to additional storms (September and October are typically the

17 Philip A. Fedora, "Reliability Review of North American Gas/Electric System Interdependency," Proceedings of the 37th Hawaii International Conference on System Sciences, 2004.

18 CECA, *Projecting Energy Needs to 2025*, white paper prepared by Booz Allen Hamilton for the CECA Fuels and Technologies Forum, Washington, DC, 2005, available at www.cecarf.org.

19 National Petroleum Council, *Securing the Oil and Gas Infrastructures in the New Economy* Washington, DC, 2001.

20 Energy Information Administration, *Short Term Energy Outlook*, September 7, 2005.

most active hurricane months). This level of price volatility strongly supports CECA's premise that a diversified fuel mix is needed as a hedge against future shocks.

The interdependence of the gas and electric infrastructures has also hampered the speed with which some facilities have come back online. As of September 8, 2005, DOE's Office of Electricity Delivery and Energy Reliability reported that four of eight natural gas facilities in the Gulf Coast were repaired but could not operate due to a lack of electricity. These outages represent 1,945 MMcfd of capacity, about one quarter of the Gulf Coast's handling capacity, and approximately 50 percent of the capacity estimated to be restorable in less than three months.[21]

## Accidental or Deliberate Human Actions

Although weather, other natural disasters, and technical and infrastructure failures constitute the primary concern for the proper functioning of the energy infrastructure, the potential for accidental or deliberate disruptions caused by human actions must be considered in infrastructure planning. Deliberate actions could take the form of a cyber attack or physical sabotage to any component of the energy infrastructure.

The energy industry, like the broader economy, has become increasingly reliant upon electronic systems and the flow of information over these systems. The volume of this information and the unprecedented speed with which it can be transferred over the publicly-switched network has made information both more easily accessible and more difficult to protect.[22] As a result, the traditional approaches to protecting infrastructure are no longer sufficient to guarantee system protection. A report by the National Petroleum Council noted that "Receipt of real-time information is critical in protecting the oil and natural gas infrastructures, and rapid reporting of incidents is vital."[23] To date there has not been a cyber security incident of a magnitude to have significantly affected consumers; however, the threat of such an event cannot be discounted.

Similarly, the energy infrastructure has not been successfully disrupted by physical attack to date. However, the threat to the energy infrastructure through sabotage or human accident is real. Several instances illustrate the point. A plot to bomb the Los Angeles International Airport prior to the Millennium celebration was foiled when a terrorist crossed into Washington State from Canada with his car trunk full of explosives. At trial, he explained that recruits at Osama bin Laden's training camps are instructed in the sabotage of electric and gas plants, as well as supporting infrastructure such as railroads.[24] Individuals armed with knowledge of the sources readily available on the internet could conceivably leverage the energy system's vulnerabilities to create significant economic and political dislocations.

Nor is the threat limited to intentional disruption. On October 4, 2001, a drunken Alaskan resident managed the improbable feat of shutting down the entire Trans Alaskan Pipeline for three days after he shot it with his rifle.[25] The Bonneville Power Administration recently caught an individual who was unbolting its transmission pylons.[26] Such acts, whether deliberately targeted at sensitive nodes in the infrastructure or merely accidental events, present the potential for significant damage across multiple infrastructures. The energy delivery systems must be protected through system redundancy, timely response, and recovery.

Due to the technical and geographic extensiveness of the energy system, policy approaches to address vulnerabilities deriving from system interdependencies must target only the most relevant threats. Generally speaking, this means identifying measures that help anticipate, mitigate, and recover from disruptions caused by system physical interdependencies. These vulnerabilities are very real and portend serious consequences and market participants have already undertaken important steps to limit the threat of physical interdependencies. As a function of the tremendous political and economic pressure upon system operators to ensure the reliability of the system, numerous policymaking bodies, including the North American Electric Reliability Council (NERC), RTOs and ISOs, utility companies, and State Public Utility Commissions, have undertaken studies and scenario planning to anticipate the risks associated with inter-systemic failures.

### CECA Forum Findings on Upgrading the Nation's Energy Systems Infrastructure

- Approximately 30 percent of total coal-generated electricity comes from coal-fired power plants that are served by a single railroad transporter. This situation may result in the captive user paying a higher price for coal than customers of competitive railroads and the higher costs may be passed on to consumers.
- Significant capital investment is needed in railroads to meet growing demand.

21 U.S. Department of Energy, Office of Electricity and Energy Reliability, *Hurricane Katrina Situation Report # 29,* September 9, 2005.
22 National Petroleum Council, "Securing Oil and Natural Gas Infrastructures in the New Economy," Washington, DC, 2001.
23 *Ibid.*
24 Frontline, "Trial of a Terrorist," Official Transcript of Program #2004, direct citation of Ahmed Ressam's Federal trial transcript, October 25, 2001.
25 CBS News, "Alaska Oil Pipeline Pierced by Bullet," October 6, 2001.
26 CECA conversation with Denise Swink, former Director of the DOE Office of Energy Assurance, January 2006.

- Waterways and barges are in dire need of upgrading and repair so that coal supplies can be moved on the nation's waterways efficiently and cost-effectively.

- Modernizing the nation's transmission system on a regional basis is critical to meeting the increasing demands for electricity. Consumers will be best served if the transmission system is upgraded to increase efficiency and reliability of electricity delivery.

- Having a reliable, robust, modern electric transmission system will help to hedge against system vulnerabilities. To do so, both public and private investment in the transmission system to alleviate bottlenecks and congestion is needed in the near term.

- Energy efficiency investments alleviate consumption at peak times, usually during summer and winter when the grid is most prone to outages. Most outages, including the blackout of August 14, 2003, occurred when the grid was operating at or near peak capacity. Because of system interdependencies, alleviating strain on the electrical system will also limit pressure on natural gas systems.

- Distributed generation—generators located at or near customer loads—provides an added bulwark against outages affecting the electric system and, to a lesser but still important extent, the gas system as well. Highly centralized energy infrastructure is inherently brittle, as a single outage in one area of the system can affect many users. By contrast, a network of small, distributed units may help provide resistance against such a failure.

- If decisions are made to increase imports of LNG to supplement domestic supply of natural gas, investment in additional terminals, pipelines and related infrastructure will be required.

- The U.S. must make a major commitment to science and engineering education and other skill sets so the skilled workforce required to design, build, and operate the nation's complex energy facilities is available.

- While protecting against all vulnerabilities of the energy infrastructure is virtually impossible, many disruptive events can be anticipated. Such events include severe hurricanes, massive blackouts, and sabotage to infrastructure.

- Markets provide a strong incentive for energy companies to procure adequate supplies to meet energy demand. Avoiding disruptions is of paramount importance to companies, as disruptions have vital implications for company performance and revenues.

## 4.3 Interdependencies of Energy System Needs and Water Availability

The interdependencies of energy and water systems and the conflicts among water-use sectors are becoming major constraints to meeting future energy needs. Lack of adequate water availability has been the reason that several power generation proposals have not been approved. In addition, constraints on water availability are one of the most significant concerns with the development of coal bed methane. Growing tension over the competition for water continues to be one of the major issues in licensing and relicensing hydroelectric projects. Currently, issues relating to water availability for energy systems are resolved on a case-by-case basis with little understanding of the wider implications of those decisions.

Competition for available water supply will significantly increase in the coming decades. Energy production is a major consumer of water, using more water annually than all other industries and competing on a par with the agricultural industry's use of water. Thermal electric power production is a large source of these withdrawals, requiring an estimated average of 25 gallons to produce one kilowatt hour of electricity. Therefore, more water is used to provide the average consumer's electricity needs than for all other consumer uses. The extraction of energy fuels, including both oil and coal bed methane, also results in significant water withdrawals. For example, approximately 10 barrels of "produced water" are pumped to the surface for each barrel of oil in the U.S. In total, the U.S. Geological Survey estimates the mining industry withdraws an additional 3.5 billion gallons/day. Clearly, water is a critical input to energy production and competition for available water will be a major factor in future energy production decisions.

Conversely, energy is a critical input to water delivery to consumers. For example, the California Energy Commission estimates that at least 10.2 percent of California's total electricity usage goes towards pumping, treating, and distributing water.[27] That amount is expected to increase as water demand grows and populations shift to the more arid West. Power requirements for treatment of water, desalination, water reuse, and water pumping for distribution will also grow substantially. As the energy needed to drive

27 Matt Trask, "Water-Energy Relationship," *Staff Paper in support of 2005 Integrated Energy Policy Report,* June 2005.

these water projects in turn requires substantial water inputs, there is significant incentive for energy planners to utilize more energy efficient water technologies and approaches.

Electric power plays a critical role in other water requirements. In 2005, Hurricane Katrina knocked out power to water suppliers and damaged or disrupted some 1,000 water systems in the South. In 2001, the Bonneville Power Administration had to curtail power deliveries to irrigation-dependent agricultural sectors of Washington and Oregon. Changes in climate patterns can impact the need for additional water and energy demands. Projections that suggest a drier climate for the Western U.S. would require drawing water from more difficult sources, resulting in a corresponding increase in power needs. These examples point out the imperative to better understand the interdependencies among such critical infrastructure sectors as water and energy. Water is a regional resource and weather and demographic changes will affect regions unequally. Watersheds are the basis for water management and planning. Energy planners must have a better understanding of constraints and opportunities at the watershed level and become more involved in watershed planning and coordination.

The CECA Forum recognized the essential role water will play in the ability to meet future energy demand and the resulting need to coordinate energy and water policy effectively. Technology solutions and research into improved management approaches in both the water and energy sectors can have a significant impact on the nation's ability to meet future energy needs. For example, the Integrated Gasification Gas Combined Cycle (IGCC) process requires significantly less water than more conventional clean coal technologies. Additional infrastructure and other upgrades in the energy sector can include improvements in cooling technologies to minimize water needs, reuse of produced water, use of non-traditional sources for process and cooling water, and the use of decision-informing tools by the institutions responsible for balancing supply and demand.

Improvements in technology will be based on economic and regulatory justification. In many regions of the country, water is undervalued in classic supply/demand economics. In some areas, water allocations are based on history or location rather than value and, therefore, few tools exist to provide incentives for water efficiency in the power sector. It is important that options for technology and implementation approaches be developed to address water/energy management.

Water management is primarily the responsibility of the States, yet a number of Federal agencies have considerable impact on the issue. Issues relating to water supply, transportation, natural resources, and environment have been the primary focus of Federal policymakers. The U.S. Corps of Engineers, the U.S. Department of Interior, the U.S. Environmental Protection Agency, and other agencies have impacted water use choices through dam management, permitting, land management, and regulatory actions. There is also, however, a great need for consideration of the consequences of water use on the nation's ability to produce the energy required in the future.

A number of initiatives have been started that may help address the energy/water nexus. The Department of the Interior's "Water 2025" initiative is intended to facilitate a public discussion of water issues and to develop a framework for meeting future water supply challenges. EPA's Office of Water focuses on watersheds and related issues, and 11 DOE national laboratories are coordinating efforts under their Energy Water Nexus initiative. The DOE's Office of Fossil Energy has recognized the critical link between power plants and water, and initiated a research program in 2003 that is directed at developing advanced water recovery and reuse technology, advanced cooling systems, and fostering the use of non-traditional water sources. The DOE is also sponsoring research to address the treatment and reuse of coal bed methane and oil/gas produced waters. Finally, Section 979 of the Energy Policy Act of 2005 provides authorization for a new research and development program focusing on ensuring adequate supplies of water for energy development. Two reports that Congress requested in the Act will document regional issues associated with the challenges of the energy/water nexus and the technology options to address these challenges.

CECA believes that energy planning must be integrated with water use planning to ensure energy and water needs are appropriately balanced. CECA also believes that meeting future energy demands will require significant coordination among planners and policymakers in the energy and water sectors. Coordination among Federal agencies and among Federal and State agencies would be most effective by identifying and implementing options in planning future water needs, minimizing risk through portfolio planning; and understanding water needs associated with energy projects.

### CECA Forum Findings on Interdependencies of Energy Systems Needs and Water Availability

- The critical interdependencies of water availability and the ability of energy systems to operate are not sufficiently understood by policymakers and the public. Energy systems require enormous volumes of water to operate properly and water systems require reliable energy to function. Future policies must consider the implications of the energy and water interdependencies;

- As demand for new energy supply increases between now and 2025, system planners will need to develop and implement new, efficient water use systems to support increased demand. Coordination among government agencies in energy and water-related decision making processes is essential.

- Research and technology developments will be required to address the growing urgency of energy/water system challenges.

## 4.4 U.S. Carbon Policy: Looking Ahead

The subject of greenhouse gas emissions and global climate change between now and 2025, the period of the CECA study, is one of the most important energy issues that policymakers will need to address. Scientists believe there is a link between the warming of the earth's atmosphere, with resulting changes in global climate, and increased emissions of greenhouse gases. Greenhouse gases[28] contribute to the greenhouse effect by trapping energy from the sun's rays in the atmosphere. While most of the world's governments, including the United States, recognize the importance of addressing climate change, their policy approaches differ. Even within the U.S., there are differing approaches to addressing climate change. A number of States have implemented some form of emissions reductions program while the Federal government focuses on a voluntary approach.[29] There is a view by many in industry that the Federal government's climate policy may change at some point. The uncertainty as to when and in what form such a policy will take is causing concern in the investment community, raising risks and costs of the needed energy infrastructure.

Climate change is a serious long-term global issue, with causes and contributors that span all sectors of the economy and all nations of the world. In 2003, the latest year for which data is available, the electric power industry in the U.S. contributed 33 percent of U.S. GHG emissions, followed closely by the transportation sector at 27 percent. Clearly, much progress can be made through the efforts of the electric power sector, although a fully effective solution to the climate change issue will require participation throughout the U.S. economy and throughout the world.

Although the debate over climate change demonstrates widely divergent views on policy approaches, there is little or no difference in the long-term goal of achieving very low or near-zero net emissions. Addressing climate change in a meaningful way will require significant changes regarding the energy technologies and fuels on which the economy relies. This type of change cannot happen easily or immediately.

The Energy Policy Act of 2005 included a number of provisions to encourage the development and deployment of climate-friendly technologies. A limited amount of investment tax credits, up to 20 percent, was provided to encourage the use of gasification technologies in the power sector[30] and Federal loan guarantees of up to 80 percent of the capital costs were authorized for a wide range of clean energy technologies including nuclear energy, renewable energy technologies (hydropower, wind power, solar power, biomass, geothermal), fuel cells, and carbon capture and storage technologies. In addition, Congress authorized a 10 year R&D program and over a billion dollars for research, development and deployment of carbon capture and storage technologies and recognized the importance of regional partnerships established by DOE to address carbon sequestration across the nation.[31] The DOE's Carbon Sequestration Leadership Forum and the billion dollar FutureGen Project are also key initiatives that will be important to achieving near-zero emissions fossil fuel technologies.

### *Global and Regional Contexts*

There are various greenhouse gas programs at the international (e.g. Kyoto Protocol), Regional (e.g., RGGI), and State levels (e.g., Massachusetts, New Hampshire, Oregon, and Washington). There are also individual State agency programs (e.g., the California Public Utilities Commission (CPUC) and the California Public Employees Retirement System (CALPERS)). However, there is currently no mandatory Federal government program on greenhouse gas emissions. Current Federal policy is based on technology development and voluntary actions and partnerships, both domestic and international. Nonetheless, many domestic and international stakeholders believe that there is a need to develop a national policy on greenhouse gas emissions sooner rather than later. The uncertainty about which national policy will or should be implemented to achieve reductions in greenhouse gas intensity and emissions in the next 20 years represents a huge issue to industry. Uncertainty results in lack of investment in new technologies, while certainty would provide opportunities for U.S. industry to invest in new technologies that could be utilized domestically and internationally.

28 Six gases comprise the bulk of the GHGs: carbon dioxide, methane, nitrous oxide, PFCs, HFCs, and sulfur hexafluoride, with carbon dioxide as the largest overall contributor based to global warming.

29 Both mandatory and voluntary approaches are technology based.

30 Gasification technologies are viewed as among the most carbon-capture-ready technologies, meaning it would be less costly to adapt these technologies to a GHG program than more conventional technologies.

31 DOE established a network of Regional Carbon Sequestration Partnerships to determine the most suitable technologies, regulations, and infrastructure needs for carbon capture, storage and sequestration in different areas of the country. These regional partnerships are in recognition that it will take a concerted effort of federal and state agencies, working in cooperation with technology developers, regulators, and others, to put into place both the concepts and the necessary infrastructure to achieve meaningful carbon reductions.

To have a meaningful impact on greenhouse gas reductions, all major emitter nations must contribute to the reduction of greenhouse gases and to mitigation efforts. International cooperation provides the added benefit of information sharing on climate-friendly technology advances and facilitation of deployment of these technologies. The Framework Convention on Climate Change, as well as bilateral and multilateral partnerships, such as the Asia-Pacific Partnership on Clean Development and Climate, are important tools for moving towards the goal of zero or near-zero GHG emissions.

## Carbon Policy

The development of a climate policy must recognize the role technology will need to play in meeting the nation's GHG-related goals. It is appropriate for government to encourage the growth of clean energy technologies in which the potential for public good is clear. Clean energy technologies include clean coal technologies, nuclear energy, renewable energy resources, and energy efficiency. Importantly, energy efficiency translates directly into reduced GHG emissions associated with generating energy.

As national policies are developed, criteria are needed to support the interests of consumers. Policy should be cost-effective. Adequate lead time for consumers and industry to adjust to the policy should be provided. Many of the investments for reducing or mitigating GHG emissions will take time to put in place. The burden of action should be distributed fairly to ensure cost to consumers is minimized.

Policymakers must view the issue in the context of an overall energy strategy to ensure climate policy is consonant with national and economic security goals. For example, clean coal technologies that include carbon capture and sequestration would address adverse characteristics of coal and meet energy security and climate goals. To improve the environmental performance of the nation's energy fuels, technologies and policy that address the adverse characteristics of each fuel must be developed.

In addition to environmental, affordability, and national security (i.e., reliance on fuels from unstable regions) criteria, climate policy involves complex issues of economy and jobs (potential reductions in industries producing significant greenhouse gas emissions, coupled with potential increases in industries involved in climate-friendly substitutions), and business planning (uncertainty can translate to higher costs). Greenhouse gas mitigation measures include energy efficiency, the substitution of highly efficient technologies in end-use applications, and technologies to improve the environmental characteristics of each fuel in the nation's fuel portfolio. The consequent reduction in the use of energy, coupled with cleaner fuels, directly translates into reductions in carbon intensity and in the emissions of greenhouse gases. Reduced utility revenues resulting from reduced generation due to efficiency investments must be addressed by policymakers.

## Effect of Carbon Policy on Fuels

As highlighted in Chapter Two, no national energy policy implemented over the next 20 years could have a greater impact on fuels for stationary sector energy needs than a shift in Federal climate change policy. In the short term, the impact for some fuels will be positive and for others it will be negative. In the long term, all fuels will benefit as new policies provide incentives for developing low-emitting and energy-efficient technologies to optimize the characteristics of all fuels.

Table 9 shows how a mandatory federal climate policy, with a strong emphasis on technology development, might affect the fuels used to meet stationary energy needs. While all fuels would benefit from such a policy, the fossil fuels would show the greatest improvement.

### CECA Forum Findings on U.S. Climate Policy

The CECA Fuels and Technologies Forum found that the increasing demand for a shift in Federal climate policy is the primary cause of uncertainty within the industry and investment communities. Because the Federal government has not enacted such a shift in policy, more aggressive movement is being generated at the State and Regional levels. The lack of a national policy adds to doubt and uncertainty for investors, equipment manufacturers, and ultimately consumers. While the CECA Forum generally agreed on the benefits of having a clear national policy instead of a myriad of State and local regulations, it was not able to reach agreement on when such a policy should be adopted or what form such a policy should take. The findings of the CECA Forum include the following:

- Energy efficiency is a critical tool in reducing greenhouse gas emissions and should be encouraged in State, Regional and Federal policies.
- The costs and benefits of all climate policy options must be carefully weighed by policymakers including consideration of the cost of compliance against the cost of waiting to take actions later.
- Because of the global nature of the climate issue, a concerted international approach is required to achieve optimal reductions in greenhouse gases. All major emitter nations must reduce greenhouse

**Table 9: Costs and Benefits for Fuels under a U.S. Climate Policy**

| | Cost | Benefits |
|---|---|---|
| **Coal** | • Central generation facilities would be impacted most because of high carbon/energy ratio. | • Would fast-track clean coal technologies, gasification, and sequestration so that the nation's abundant coal supplies can be used. |
| **Natural Gas** | • Would see significant spike in demand, straining production and supply lines and increasing price. | • Higher prices would encourage exploration of non-conventional sources (e.g., coal bed methane and syngas from coal or biomass). |
| **Oil** | • Demand for traditional heating oil could decrease. | • Demand for higher blends of heating oil/ biodiesel would increase. |
| **Nuclear** | • No real costs | • Would become more competitive with fossil generation. |
| **Renewables** | • No real costs | • Would become more cost competitive with fossil generation. |
| **Energy Efficiency** | • No real costs | • Would benefit from increased demand for energy saving/conserving appliances and equipment. |

gas emissions. The U.S. should play a leadership role in addressing global climate issues.

- Support for research and development into clean energy technologies for all fuels is an essential element of any climate policy. Such technologies will allow the energy industry to undertake emissions reductions more rapidly and with less cost. Opportunities are ripe for U.S. industry to market these technologies internationally.

# Fueling the Future:
## Better Ways to Use America's Fuel Options

# Chapter Five:
# Conclusions and Recommendations of the CECA Forum

## 5.0 CECA Forum Conclusions and Recommendations

The policy recommendations provided in this chapter are intended to guide policymakers in Congress, other Federal agencies, and the States in making decisions on fuels and technologies policy to meet U.S. stationary energy needs over the next 20 years. The recommendations focus on ways to optimize the broad portfolio of fuels and technologies required to meet the National Consumer Priorities established by the CECA Forum, including affordability, environmental responsibility, reliability of supply, and security and safety of energy systems.

The CECA Forum's conclusions and public policy recommendations are organized consistent with the discussion of policy issues in Chapters Three and Four, as follows: (1) Fossil fuels and related technologies, including coal, natural gas, oil, and issues of distributed generation and combined heat and power; (2) Nuclear energy; (3) Renewable energy resources, including hydropower, wind power, solar power, and biomass; (4) Energy efficiency; and the cross-cutting issues that affect all fuels and technologies in the stationary energy portfolio; including (5) Research and development; (6) Infrastructure; (7) Interdependencies of energy system needs and water availability; and (8) Climate policy.

## 5.1 Fossil Fuels

Coal, natural gas, and oil supply over 80 percent of the current energy needs of the stationary sector. As pointed out in Chapter Two, demand for fossil fuels is projected to grow significantly over the next 20 years. An overriding consideration in discussing future opportunities for coal, natural gas, and oil in meeting stationary energy needs is ensuring the availability of supply in ways that meet the National Consumer Priorities. This entails focusing on barriers that need to be overcome, including infrastructure investments, interdependencies of fuels, non-economic constraints in supply, and improved environmental performance.

### CECA Forum Conclusions on Coal

Coal is the nation's most abundant fuel source, both in terms of supply and infrastructure. The price of coal and coal production should remain at competitive rates through the 2025 period of this report. As such, the U.S. will continue to depend on coal to play a critical role in meeting future domestic energy demand growth. However, coal also has substantial environmental challenges, which will increase as the domestic and global coal resource base and infrastructure grow. Traditional coal-to-power combustion methods do not fully attenuate these environmental challenges.

New regulations governing the emissions of NOx, $SO_2$, and mercury provide additional requirements for existing coal-fired power plants. Technologies may need to be developed to meet latter stages of some of these new requirements and research and demonstrations are necessary for new control technologies necessary for compliance by the existing power generation fleet.

### Clean Coal Technologies

The Energy Policy Act of 2005 takes a strong step forward in promoting the next generation of coal-fired power production by providing incentives for Integrated Gasification Combined Cycle and other qualifying technologies. However, the incentives do not equally promote all potentially viable advanced coal technologies. Nor are many of these incentives applicable to rural electric cooperatives or other non-tax-paying entities. Finally, the tax credits are limited in amount such that they will be applicable to only four to six plants of the many dozens that will be needed over the next 20 years, while the development of the Federal loan guarantee program has been delayed over implementation issues.

Furthermore, current emissions requirements do not properly account for the ultimate costs and externalities to consumers from traditional coal combustion technologies. To best meet consumer and environmental requirements, the market for coal infrastructure growth must be dominated by the most environmentally friendly advanced coal technologies available. In that regard, it is important that the entire life cycle of coal processes, from coal mining through stack emissions, be considered. One environmentally-friendly clean coal pre-combustion technology, coal beneficiation, treats coal in such a way that reduces water content, thus increasing the efficiency of the coal. Pre-combustion clean coal methods are not widely used and research and development funds are needed to expand such clean coal technologies.

Among the environmental challenges to the greater use of coal is the need to limit the emissions of mercury. The Clean Air Mercury Rule, promulgated by the Environmental Protection Agency in 2005, takes steps to address contributions to regional and global mercury accumulation by U.S. power generators. However, U.S. policy alone cannot fully address the risks to U.S. consumers. More than half of local mercury emissions enter the global mercury cycle, and scientific evidence increasingly points to foreign sources of mercury as a significant source of deposition in the U.S.

As the energy fuel with the greatest carbon content per unit of energy, coal's role in the nation's future energy portfolio requires investment in carbon capture and storage technologies and continuing concerns over global climate change will drive the need for more climate-friendly technologies. However, the state of current technology for carbon capture and sequestration can involve a significant increase in the cost of electricity and significant technical uncertainties.

Opportunities exist for using coal to meet the nation's energy needs outside the electric power sector. Technologies exist to convert coal to liquid fuels suitable for diesel and other applications in the transportation sector. Research is needed to demonstrate the economic and environmental performance of these technologies on a full range of U.S. coals, as well as research into approaches that can reduce the cost of the technologies. Technologies also exist to convert coal to syngas, a potential substitute for a wide range of natural gas needs by the industrial sector. Large scale applications are demonstrated on a limited scale for producing feedstock for certain products of the chemical and fertilizer industries. Research needs to be performed to identify additional capabilities in those industries. Economic smaller scale applications for glass, paper, steel and other sectors are only just being considered. Research into technologies that can be economic for these industries must be planned and undertaken.

Finally, coal's abundance suggests a potentially large role in the development of a hydrogen-based energy economy. Coal is one of the energy fuels from which hydrogen can be produced. DOE has been developing a pilot near-zero-emissions coal-fired power plant, referred to as FutureGen. FutureGen, a public/private partnership involving both the Federal government and coal producers and utilities, is intended to demonstrate the latest technologies for development of hydrogen, carbon sequestration, gasification, and other technologies necessary for meeting the nation's future coal-related energy needs.

## CECA Forum Recommendations on Coal

1. *CECA recommends that commercial processes and advanced clean coal technologies comprising the entire coal fuel cycle be promoted with increased funding for demonstrations and incentives to facilitate widespread deployment, leading to increased efficiency and reduced environmental consequences. Further, CECA recommends:*

   - *Expedited implementation of the loan guarantee programs authorized by the Energy Policy Act of 2005 and strongly urges Congress to appropriate funds to allow non-fee-paid projects to take advantage of these programs.*
   - *Expansion of the investment tax credit for clean coal technologies beyond the initial limitation to allow for more widespread deployment and more diversity in application and technology.*
   - *Full funding of increases in the clean coal research program as authorized in the Energy Policy Act of 2005 and expansion of this program to incorporate research leading to increased use of coal-based fuels for transportation and industrial use.*

2. *CECA further recommends the advancement of clean coal technologies, including Integrated Gasification Combined Cycle (IGCC), and recommends full or increased support for the programs and funding levels in the Energy Policy Act of 2005, specifically:*

   - *Increased funding for carbon sequestration programs to allow continuation of Regional Partnerships, extensive research and development efforts on carbon capture and sequestration techniques, and large-scale demonstration of promising technologies.*
   - *Increased funding for the integrating technologies necessary to produce capture-ready streams of carbon dioxide in coal-fired generating plants, as well as gasification and hydrogen separation technology.*

- *Increased funding for research on innovative commercial demonstrations of clean coal technologies, combustion systems, fuel cells, research into the applicability of different coals for IGCC technologies, coal to liquids technologies that produce diesel fuel and gasoline, and power plant water management technologies.*

3. *CECA supports the development of FutureGen, a near-zero emissions coal plant, and recommends that this facility be closely integrated into the research, development, and demonstration of innovative technologies taking place in other fossil energy programs to assure their demonstration in the FutureGen facility.*

4. *CECA recommends that in developing a mercury regulation the Federal government look at all sources, not just stationary ones. CECA further recommends that:*

   - *Policy is created accounting for all technology and process solutions which remove mercury and reduce mercury emissions, from pre-combustion to post-combustion.*

   - *The Federal government take a leadership role in convening an International Conference on the international transport of airborne mercury to highlight the magnitude of the problem and to develop a strategy for international cooperation on mitigation and standards, including a cap-and-trade program which would complement that developed in the U.S.*

### CECA Forum Conclusions on Natural Gas

The nation is facing serious ramifications of rapid escalation of natural gas prices coupled with domestic supply shortages and international competition for global supply. Options for filling the gap include such non-conventional sources as LNG, assuming safety, siting, and other concerns can be addressed, as well as coal bed methane, tight sands, deep gas, and the more environmentally sensitive areas in the Rocky Mountain region, all of which present risks to development.

## Development of Domestic Resources

The development of domestic resources, including gas from Alaska, needs to be considered. Proven reserves of natural gas from the Alaska fields are estimated at 35 trillion cubic feet (tcf). However, moving that gas to the regions of the country that need it requires a substantial infrastructure investment, which has yet to be forthcoming. Beyond Alaska, the U.S. needs to invest in technologies to develop more difficult resources such as those found in deeper levels or in hydrate form. To address these issues, Congress indicated its interest in the development of the Alaska Natural Gas Pipeline through provisions in the Energy Policy Act of 2005. The Act also calls for the establishment of a new ultra-deep and non-conventional gas program.

Methane hydrates are gas deposits that are trapped in marine sediments. The United States Geological Survey estimated the in-place methane hydrate resource within the United States at approximately 200,000 tcf.[1] Developing this resource in an environmentally sound manner requires a significant investment in data gathering, drilling and production techniques, and an assessment of the impact of hydrate development on the environment.

Finally, technologies need to be developed to produce syngas from coal and biomass economically to be used as a substitute for natural gas. Industry accounts for over a third of the nation's natural gas consumption and syngas has the potential to meet much of this need.

## Imports of Liquefied Natural Gas

In addition to increasing the nation's domestic natural gas resource, there is serious consideration of the need for greater imports of liquefied natural gas to help meet future U.S. natural gas demand. To ensure that the projected increased reliance on imports meets the National Consumer Priorities articulated by the CECA Forum, issues regarding safety of LNG facilities, dependence on foreign supply sources, security concerns, balance of payments issues, and siting and cost considerations must be resolved. In addition, the LNG infrastructure will need to be improved and assurances must be made that the use of LNG is compatible with the existing natural gas infrastructure.

A significant portion of the domestic natural gas infrastructure is located in the Gulf of Mexico, while natural gas demand is heaviest in the Northeast, Midwest and Western regions of the nation. This disparity in the infrastructure/demand scenario results in significant reliance on the interstate natural gas pipeline system to move available supply to high demand regions. In addition, hurricane activity in 2005 has demonstrated the vulnerability of having a large concentration of U.S. energy infrastructure in the Gulf of Mexico. Based on these supply/demand factors, there is a need to design a national natural gas policy which will alleviate physical and cost pressures on the existing pipeline system to the benefit of consumers.

### CECA Forum Recommendations on Natural Gas

5. *CECA recommends that Federal and State regulators use their siting authority to ensure that if LNG is imported, the location of facilities should be diversified to the*

1 DOE Fossil Energy Program, "Methane Hydrate - The Gas Resource of the Future," based on 1995 USGS study as updated in 1997.

*extent possible. Given public concern over the safety and siting of LNG facilities, CECA also recommends that such facilities not be placed in close proximity to major population centers and that development of offshore LNG facilities be encouraged.*

6. *CECA recommends that the U.S. Department of Energy develop standards on the impacts of LNG on combined cycle generation facilities to ensure that the existing natural gas power infrastructure is compatible with the use of LNG and that liquid BTU content standards be developed.*

7. *CECA supports increased research and development of technologies and approaches to develop non-conventional sources of natural gas, including methane hydrates, ultra-deep water development, deep gas formations, coal bed methane, shale gas, and syngas from coal or biomass, and encourages the expeditious implementation of such requirements contained in the Energy Policy Act of 2005. Funding for methane hydrates should focus on determining whether the economic and environmentally responsible development of such resources can play a major role in fulfilling the nation's energy needs over the next 20 years.*

## CECA Forum Conclusions on Petroleum and Oil for Home Heating

There has been upward pressure on energy prices for residential consumers over the past several years. While the majority of oil is used for transportation purposes, which is outside the scope of the CECA Forum, the ramifications of rising energy prices can have a substantial impact on homeowners.

The heating oil industry has an ideal opportunity to use alternative and renewable fuels and is already taking a leadership role in doing so. For example, bioheat, a mixture of heating oil and processed vegetable oil-based diesel, is being used by a growing number of heating oil dealers in the Northeast. CECA supports the encouragement of bioheat and other alternative fuels through research and other means to provide homeowners the unique opportunity to heat with a domestically produced renewable fuel with a very low emissions profile. Such fuels also help hedge against petroleum price swings.

In addition, CECA believes that a better understanding of energy efficiency measures for heating and hot water is warranted. CECA supports public education efforts to enable consumers to make smart economic choices regarding home heating. The AFUE system—which calculates the efficiency of a heating system by measuring the amount of heat delivered against the amount of fuel supplied—provides useful information, but industry and efficiency experts believe that the AFUE system is incomplete and not a realistic predictor of actual home energy use. CECA supports the development of testing and standards procedures to replace the AFUE system so that consumers will have more accurate information on which to base purchasing decisions and reduce energy consumption.

## CECA Forum Recommendations on Petroleum and Oil for Home Heating

8. *CECA recommends that the Federal government increase funding for biofuels research for heating oil and other applications while also providing increased funds for consumer education on cost-effective energy efficiency measures such as upgrading inefficient burner tips, installing insulation and efficient windows, sealing air leaks in framing and ducts, automatic setback thermostats, and other effective energy-reducing measures. Additionally, CECA recommends that the industry, through the National Oilheat Research Alliance, work with Brookhaven National Laboratory and other Federal laboratories and State agencies, such as the New York State Energy Research and Development Authority, to develop an improved method of evaluating the efficiency of home energy systems and of home heating appliances.*

## CECA Forum Conclusions on Distributed Generation and Combined Heat and Power

Distributed generation and combined heat and power systems may provide consumers with the opportunity to locate their power source on-site or close to the point of use and thus realize cost reductions resulting from reduced transmission costs and increased fuel efficiency. Co-location of heat recovery facilities in industrial applications can render useful heat that would otherwise be wasted. While the cost of DG and CHP systems is often competitive with electricity provided by electric utilities, DG/CHP systems have not yet penetrated the market deeply. Nonetheless, it is CECA's belief that DG/CHP can and should play an important role in the marketplace as a complement to central station generation.

The lack of market penetration by DG/CHP is due to a range of factors, including difficulties in safely interconnecting the systems to the grid and complexities in formulating the charges utilities levy to provide standby power. Concerns regarding pricing for DG/CHP systems stem from rate designs that do not provide the appropriate systems price signals to prospective DG/CHP host facilities, which may obscure the true cost of electricity.

### CECA Forum Recommendations on Distributed Generation and Combined Heat and Power

9. *CECA supports the move towards a regulatory environment that is conducive to the implementation of clean and efficient DG/CHP systems and addresses barriers to the deployment of CHP systems in the marketplace. Therefore:*

   - *CECA recommends that the Federal Energy Regulatory Commission (FERC) adopt revisions to the IEEE SCC21 P1547 interconnection standard as they are developed with respect to distributed generation resources for those generators that come under FERC's jurisdiction.*
   - *CECA recommends that State Public Utility Commissions develop fair and equitable rate designs, standby tariffs, back-up requirements, and net-metering or other rules designed to promote widespread implementation of cost-effective, clean and efficient DG/CHP projects.*

## 5.2 Nuclear Energy

### CECA Forum Conclusions on Nuclear Energy

Nuclear energy constitutes a key pillar of the stationary sector energy portfolio, fueling 21 percent of the electricity generated within the United States. As pointed out earlier in this report, if key legislative incentives have their intended effect, demand for electricity from nuclear energy technologies will grow significantly over the next 20 years. This would constitute a major shift in the nation's baseload generation mix.

The need for affordable and reliable power that does not emit greenhouse gases has prompted renewed interest in nuclear energy. The performance of existing U.S. nuclear plants has steadily improved over the past 25 years, and advanced nuclear plant designs with enhanced safety features are available. Through these improvements, many of the past concerns about nuclear energy in the U.S. have been addressed. The most significant remaining uncertainties involve capital cost, the regulatory approval process, the disposition of used fuel, and concerns about safety and proliferation. Congressional support for new nuclear facilities is gaining, as evidenced by the incentives provided in the Energy Policy Act of 2005. These incentives are designed, at least in part, to address the capital cost and some of the regulatory uncertainties of nuclear power – especially for the "first movers." To ensure nuclear power plays a significant role in our future energy portfolio, energy policymakers need to address issues of public concern.

Although DOE and industry programs, along with provisions in the Energy Policy Act of 2005, help reduce concerns about the licensing process, some of the regulatory uncertainty relates to systemic issues with regulatory and administrative processes. There is a need to review these processes for opportunities to improve efficiency and effectiveness, documenting process improvements, while maintaining the NRC's strong regulatory oversight.

A continuum of nuclear energy technology development, requiring R&D support beginning now, would facilitate deployment of the full suite of technologies on a prioritized schedule that focuses, first, on near term deployment of Advanced Light Water Reactors (ALWRs) and implementation of an integrated used fuel management system, including centralized storage and the Yucca Mountain repository.

Support for longer-term nuclear energy technology development could enable nuclear energy to generate hydrogen and process heat for various industrial uses, as well as advanced fuel cycles and reactor technologies that can utilize the full energy content of natural uranium, which would dramatically increase available supplies of nuclear fuel for future generations.

### Used Fuel Management and Recycling

If nuclear energy is to expand significantly, the long-term issue of storage and disposal of used nuclear fuel must be addressed again by the Administration and Congress. While onsite storage of used nuclear fuel is not the optimal strategy, this approach is recognized to be safe for periods of 50-100 years. A permanent strategy, endorsed by many scientific studies and supported by Congress over the last two decades, is to develop deep geologic storage facilities.

Although Congress approved the designation of the Yucca Mountain site in Nevada as a permanent disposal facility in 2002, the development of the repository has remained controversial and licensing and construction is currently behind schedule. To complicate this issue of national storage and disposal of used nuclear fuel, by 2010 U.S. nuclear power plants and defense reactors will have generated the maximum amount of used nuclear fuel that is allowed by current law (70,000 metric tons) to be stored in Yucca Mountain. The physical capacity of the Yucca Mountain repository is considerably larger, but Congress would need to authorize expanded storage consistent with real capability or prepare for the difficult process of seeking additional repository sites elsewhere.[2] New nuclear construction can resume without expanded spent fuel storage capacity as a prerequisite, but in the long run, if the nation is to provide for a major expansion

2 Under the Nuclear Waste Policy Act, the Secretary of Energy is required to report to Congress no sooner than January 1, 2007 but no later than January 1, 2010 on the need for a second repository (although NWPA also directed waste disposal to begin in 1998 as well.

of new nuclear facilities, significant new used fuel storage capacity will be required.

One element of a long-term solution that is being considered by DOE is implementation of spent fuel reprocessing and the recycling of used fuel in commercial reactors. This strategy would also require a new generation of separation capabilities, advanced fuel fabrication, and fast spectrum reactors that can consume long-lived components in used fuel. However, reprocessing and recycling strategies do not eliminate the need for ultimate storage of waste materials – the Yucca Mountain repository is essential under all scenarios. Failure to create an adequate process to address the issue of long-term management of used nuclear fuel will affect investment in nuclear technologies.

Current technology recycling does not avoid the need for a repository or repositories for used nuclear fuel since the process only eliminates a portion of the waste. Even advanced recycling technologies, which would allow for the consumption of long-lived radioactive isotopes, will produce wastes that will require long-term isolation from the environment. If the nation is to meet its goal of a diversified fuels portfolio through the 2025 period of the CECA study, advanced nuclear fuel cycles, such as are being undertaken as part of the DOE Advanced Fuel Cycle Initiative, should be developed. These research, development and deployment initiatives are needed to significantly expand nuclear fuel supplies and to reduce the volume of toxicity and waste that is destined for permanent storage.

Reprocessing technologies available today that separate and recycle plutonium are costly and present proliferation risks. The secure, abundant and relatively inexpensive world-wide supply of uranium suggests that the U.S. has plenty of time to develop more proliferation-resistant and less costly fuel reprocessing technologies, which will eventually be needed to greatly expand nuclear fuel resources. Advanced fuel cycles will help increase the energy yield from nuclear fuels and reduce waste management burdens. It may be possible for reprocessing and fuel recycle to be done in a manner consistent with non-proliferation goals. Because of the lead time required to address the extensive technical challenges, R&D in advanced fuel cycles is needed.

Options to address non-proliferation risks include strengthening the ability of countries to implement and enforce existing export control mechanisms, increasing incentives for not developing uranium enrichment and spent fuel reprocessing facilities (including developing global solutions to spent fuel disposition), and decreasing the risk or consequences if countries withdraw from non-proliferation treaties. The GNEP proposes to address some of these concerns.

## Nuclear Waste Fund Reform

Utilities generating nuclear energy pay a fee of one-tenth of one cent for each kilowatt-hour of electricity sold by nuclear facilities in order to finance the permanent disposition of nuclear waste. These costs are passed along to consumers in their utility bills. These fees are placed in the general Treasury under the Nuclear Waste Fund and then appropriated to the U.S. Department of Energy to support the planning, construction, and operation of the nuclear waste repository and the related spent fuel transportation system. However, as a result of changes in Federal budgetary practices embodied in the Budget Reform Act of 1992, receipts from the Nuclear Waste Fund are no longer designated solely for the purposes of the Nuclear Waste Policy Act but are used to pay for discretionary activities of the Federal government. Therefore the used fuel repository program must compete for funding with other non-Nuclear Waste Policy Act activities undertaken by the Federal government.

## Public Perception of Nuclear Energy and Infrastructure

Public concerns about nuclear energy have played a considerable role in the fact that no new nuclear power plants have been ordered in the U.S. since the Three Mile Island accident in 1979. The nuclear energy industry faces issues that are common to other sectors of the energy industry, but it also must contend with issues that are unique to it. Where the similarities between the nuclear energy industry and the rest of the energy industry diverge is that its history is marred by the well-publicized accidents at Three Mile Island and Chernobyl.

Actions taken to improve public acceptance of nuclear energy will need to highlight the maintenance of the industry's safety record, and will depend on a continuation of the safe and reliable performance of U.S. industry over the past 25 years. The importance of maintaining safe operations world-wide is evident from the impact of the Chernobyl accident. Even though that reactor design incorporates an outmoded and in many ways an unsafe technology that could not be licensed in the U.S., the accident does demonstrate the importance of skilled training, attention to procedures, and vigilance. The industry and the regulatory agencies have an obligation to educate and inform the general public and policymakers on the stringent regulatory environment in the U.S., safety programs and effectiveness, and other matters that address concerns important for the industry's expansion.

Objective, third party public education about the pros and cons of nuclear energy issues, including safety, management of used fuel, siting of facilities, proliferation, and other issues will be essential in educating the public on the current state of the nuclear industry and the role nuclear energy plays in a diverse fuels portfolio. Additionally, a multi-agency program established by the Federal government would be valuable in addressing the material and human infrastructure needs of the nuclear energy industry.

### CECA Forum Recommendations on Nuclear Energy

10. *CECA recommends that DOE and the U.S. Department of the Treasury expeditiously implement aspects of the Energy Policy Act of 2005 that support accelerated expansion of nuclear energy, including implementing the standby support, loan guarantee, and production tax credit provisions of the Act. Priority actions should include providing resources to complete the standardized first-of-a-kind engineering and demonstration of three advanced nuclear designs, which incorporate enhanced safety and reliability features, as well as resources to support early site permitting and combined license demonstrations.*

11. *In recognition that an optimal used nuclear fuel management system should incorporate a combination of short and longer-term measures:*

    - *CECA recommends that DOE implement surface or near-surface interim storage measures to enable storage for a period of 50-100 years at secure federally regulated sites and that NRC and Congress evaluate the need for implementing regulations.*
    - *CECA recommends that DOE and the Congress take the necessary steps to initiate the use of Yucca Mountain as an In-Repository Monitored Retrievable Storage Facility.*
    - *CECA recommends that DOE and the NRC expedite the licensing of Yucca Mountain as a used nuclear fuel repository while not compromising safety concerns or public participation in the process.*

12. *CECA recommends that DOE undertake an R&D program focused on advanced nuclear fuel cycles, including advanced reactor designs capable of burning the long-lived components in used nuclear fuel.*

13. *CECA supports the concept of a new nuclear fuel supply and spent fuel take-back regime. CECA further recommends that DOE and the U.S. State Department press for significant strengthening of the non-proliferation regime, and continue to discourage excess inventories of separated plutonium worldwide. Specifically, the U.S. should work with individual countries and with the International Atomic Energy Agency to protect against theft of nuclear material and the clandestine use of enrichment and reprocessing facilities for weapons development, as well as improvement of capabilities to detect diversion of nuclear materials.*

14. *CECA recommends that Congress remove the Nuclear Waste Fund from the Congressional budget process, so that all monies currently in the Fund and those to be collected in the future from ratepayers are allocated solely for the purpose of developing interim and long-term storage and disposal of nuclear waste, along with associated transportation systems.*

15. *CECA recommends that DOE support activities to provide the public and policymakers with clear, impartial and balanced information so that the risks and benefits of nuclear energy can be assessed and decisions made based on objective analysis. The public education efforts should address issues relating to the safety profile of current generation technology, security and non-proliferation measures being undertaken, nuclear energy's profile as a greenhouse gas-emissions-free resource, and short- and longer-term options for the safe storage of used nuclear fuels. CECA further recommends that DOE support the efforts of objective, third party organizations to undertake such public education efforts.*

## 5.3 Renewable Energy Resources

### CECA Forum Conclusions on Renewable Energy Resources

Concern over global climate change is one of the key drivers in the decision to deploy renewable energy resources, efficiency, and other non-carbon emitting technologies. A major driver in carbon constraint is the technologies required to improve the environmental characteristics of each fuel. In addition, the form that such a carbon constraint will take, in itself, will affect future consumption patterns. A cap-and-trade and an efficiency-based regime are two of the most widely discussed policy options for addressing climate change. CECA believes that the likelihood of a carbon constrained scenario is high within the 2025 timeframe of this study.

### Renewable Portfolio Standards

Credit goes to State governments and private partners for taking a leadership role in developing the nation's renewable resources. The uneven geographic distribution of renewable energy resources is only one reason to continue to look to the States for leadership in the development of the nation's renewable resources. Federal and State programs should be reviewed and implemented in a collaborative partnership. State portfolio standards have given States the ability to bring new renewable energy technologies on-line. Moving forward, Federal research and development efforts should recognize and complement State research programs. By working together, the Federal and State efforts will maximize their effectiveness.

While acknowledging a State's particular resources, each State's renewable energy portfolio should be balanced and contain a broad assortment of renewable resources to reduce dependency on a single renewable resource. A diverse portfolio of renewable energy resources will promote a long-term future of balanced development for all renewable energy resources.

## Renewable Energy Resources R&D

There are constraints on State efforts to develop renewable energy resources, primarily because of the need for research into improvements in technologies and their deployment. The benefits of such research extend beyond the individual State lines and an uncoordinated research effort would be an inefficient use of public funds. The Federal government can continue to serve as the primary technology research and development vehicle for renewable energy technologies and the States can serve as effective laboratories for innovation. As such, the Federal government should make a major commitment to encourage innovation and deployment of renewable energy resources at the State level. Additional funding to the States is necessary to encourage markets, infrastructure development, creative public-private partnerships, and transitioning new technologies to market.

Since the 1970s, public and private R&D funding for renewable energy technologies has been in steady decline. CECA believes that a fund that both assists the States in developing their renewable energy resources and provides for a coordinated large scale research effort is in the national interest. Paying for such a fund given current budget constraints requires exploring alternatives to the conventional appropriations approach. One option could be a form of Public Benefits Fund, similar to that employed by a number of States, perhaps tied to interstate electricity transmission. Other options should be considered as well.

The uneven geographic distribution of renewable resources also dictates the need for increased cooperation to ensure interstate access to energy derived from those renewable resources. States that have renewable mandates should be allowed to count energy brought into the State which was generated in others. Regional bodies such as Regional Transmission Organizations (RTOs) or Independent System Operators (ISOs), where they exist, may be in a good position to support such coordination efforts.

## Hydropower Resources

Hydropower is a vital component of a clean, secure, and diversified energy system, and it is a low-cost and abundant resource for consumers. CECA believes hydropower will continue to play an important role for years into the future. The course is set to recognize hydropower's role as a major national source of clean energy.

Congress recognized the importance of encouraging hydropower growth and development through its inclusion of qualified hydropower in the production tax credit provisions of the Energy Policy Act of 2005. The Section 45 production tax credit serves as a valuable tool to encourage new hydropower development. Under current law, energy must be produced by January 1, 2008 to qualify for the credit. Planning, financing, equipment procurement, stakeholder consultation and agreement, and regulatory involvement, followed by construction and commissioning, can take longer than two years. A longer window of time for the tax credit is needed to encourage the hydropower industry to bring new low-cost, domestic energy to our nation's power supply.

The Section 45 production tax credit currently does not include the development of hydropower facilities at non-hydropower dams. Expanding the tax credit to this category of hydropower could enable the nation to better realize the full potential of new hydropower development at sites where it is environmentally and financially feasible.

On the research and development side, Congress recognized the importance of hydropower research and development with provisions in the Energy Policy Act of 2005. Hydropower research and development and new technologies hold great promise for future energy delivery. Through a federal/private collaborative research and development effort, advanced hydropower turbine designs have produced more energy while improving fish passage. This important work needs continued federal support. CECA supports research and development appropriations necessary for emerging technologies to demonstrate the contribution they can make to a secure, renewable energy future.

## Integration and Interconnection of Renewable Energy Resources into Regional Electric Grids

Generation plants utilizing renewable energy resources have a number of atypical characteristics compared to traditional fossil-fuel fired generation plants. These characteristics complicate the integration of these resources into the transmission grid and include such factors as the pattern with which the resources provide power (intermittency, non-peak hours, or otherwise not dispatchable) and the placement and scale of these generation resources (smaller facilities or in remote locations).

The solutions for funding interconnection to the transmission system for these sometimes challenging renewable energy resources can be found in new mechanisms which support investment in clustered renewable energy resources. CECA supports investigating alternative funding mechanisms by States or Regions or by modifying FERC's current interconnection rules so that investment in clustered renewables and/or renewable energy resources in remote locations can be more fully supported by investors when consumer costs and benefits have been carefully considered.

In addition, CECA supports expanding FERC's authority to extend the nation's Regional transmission system backbone, including the extension of such a backbone system to areas of substantial renewable potential when the benefits of such expansion outweigh the costs.

### *CECA Forum Recommendations on Renewable Energy Resources*

16. *CECA recommends that Congress pass legislation which outlines a major national commitment to increased deployment of renewable energy resources, via a framework which:*

    - *Encourages States to consider developing a plan for renewable energy resource development and increased energy efficiency investment. The plan should include an evaluation of the State's renewable energy resources and efficiency programs, State priorities on the use of R&D funding, and the means by which the State would encourage renewable markets and increased efficiency. This should include, but not be limited to, infrastructure development, creative public-private partnerships, and any State requirements pertaining to renewable energy resources, as well as reliability, environmental siting issues, and interconnection issues;*

    - *Creates a national fund to provide support to States in promoting aggressive progress towards deployment of renewable energy and energy efficiency infrastructure, market development, and research. The fund should support development and implementation of State plans discussed above as well as broad-based technology research. Criteria for the allocation of the funds to the States should be developed by DOE through a public, collaborative process involving a broad group of stakeholders and should be designed to allow for the participation of all generators, including municipal utilities and rural cooperatives; and*

    - *Encourages State cooperation in interstate trading of renewable energy and energy efficiency credits to allow for interstate sale of renewable energy.*

17. *CECA recommends that R&D funding necessary to identify, develop, demonstrate, and deploy breakthrough technologies applicable to renewable energy sources, such as nanotechnology applications to solar energy, be elevated in national priority.*

18. *CECA recommends that the States, either working bilaterally through Regional State Committees or through organizations such as the National Association of Regulatory Utility Commissioners, resolve issues such as interconnection rules across State lines and interconnection to facilitate usage of more intermittent renewable energy resources.*

19. *CECA recommends that Congress expand FERC's authority under the Federal Power Act to devise cost recovery mechanisms whereby investors of small, clustered renewable energy resources or renewable resources in remote locations can share reasonable cost allocation of such investment with ratepayers after a transparent stakeholder process that includes a hearing and comment process in which the costs and benefits to consumers are carefully considered and it is determined that consumers will benefit. CECA also supports alternative mechanisms that might be developed by individual States to provide such support.*

20. *CECA recommends that Congress act to fully implement the incentives for hydropower production and research and development contained in the Energy Policy Act of 2005. In addition, Congress should extend the placed-in-service date for the Section 45 production tax credit for hydropower to 2015, expand the credit to include hydropower development at non-hydropower dams, and fully fund the hydropower incentive payment and research and development provisions.*

21. *CECA further recommends that Federal and State policies encourage the development of small hydropower facilities and emerging hydropower technologies.*

## 5.4 Energy Efficiency

### *CECA Forum Conclusions on Energy Efficiency*

Energy efficiency is an essential element in meeting the nation's future energy needs. To meet energy demand in the 2025 timeframe of the CECA study, it is imperative that the nation embrace efforts to expand and promote energy efficiency measures that result in decreased energy consumption, decreased air emissions, and increased diversity of fuel supply. The goal for policymakers should be the creation of incentives for energy efficiency equal to those of building new generation. Many States have moved ahead of the Federal government in promoting energy efficiency measures and much can be learned from these State efforts. National attention should be focused on promoting energy efficiency measures, generation and delivery systems, and market structures that reward energy efficiency.

In encouraging utilities to support additional efficiency programs, policymakers should consider the financial impact decreased demand has on utility finances and this impact should be addressed in ratemaking actions. Even though distribution utility costs are largely fixed in a given year, revenues are still typically based on volumetric sales. This means that if sales are lower than forecast, revenue is reduced; the converse is true for above-forecast sales. Even though overall returns are nominally regulated, the effect on earnings in a given year can be strongly affected by variations in sales. Some States have decoupled revenues from sales through rate adjustment mechanisms.

However, increasing the nation's energy efficiency should not be the sole responsibility of the utilities. Incentive structures should recognize the numerous public benefits associated with increased efficiency which justify a role for government. Many States have developed effective energy efficiency programs. The Federal government should be mindful of existing successful State programs and ensure its policies are not inconsistent with State programs and plans.

The American consumer benefits from international energy efficiency efforts, through reduced demand, and thus price, for energy fuels and reduced global emissions. The U.S. should play a leadership role in encouraging energy efficiency internationally and take the lead in energy efficiency technology development. Additional, the U.S. should take the leadership in providing technological assistance to developing nations. DOE efforts in providing such technical assistance can be greatly expanded.

Among the most significant policy directions that can be taken to encourage additional energy efficiency are appliance efficiency standards and building codes, Energy Efficiency Resource Standards (EERS), and regulatory reform policies to separate utility revenues from energy sales throughput. DOE should move aggressively to fulfill and enforce the requirements for efficiency standards in the Energy Policy Act of 2005. The EERS approach sets performance targets and charges program operators with designing the most cost-effective programs to reach those targets. The Energy Policy Act of 2005 calls for a DOE study and authorization of a pilot program to assist five or more States to test this approach. CECA fully supports this mandate and encourages DOE to move forward with this requirement.

The requirements in building codes are largely responsible for the substantial drop in heating and cooling energy use per square foot in residential buildings over recent decades. Yet because building codes continue to be a State and local issue, adoption and enforcement of these energy codes remains very uneven across the U.S. The Energy Policy Act of 1992 mandated States to consider adopting the International Energy Conservation Code (IECC). A key policy priority should be creating additional funding to help States adopt and enforce the IECC.

Decoupling utility revenues from throughput is a key element for efficiency to remove the link between revenues and sales so that sales decrements from efficiency do not negatively impact revenues or profits. CECA supports designing ratemaking mechanisms in which a utility's costs are recoverable, even though sales volume is reduced because of efficiency measures or other demand-side programs.

## CECA Forum Recommendations on Energy Efficiency

22. *CECA recommends that the Federal government implement the following energy efficiency measures and methods:*

    - *Promote regulatory reform to achieve decoupling of utility revenue from energy sales throughput so that energy efficiency investments by the utility sector are more attractive to both consumers and utilities;*

    - *Accelerate the Energy Efficiency Resource Standards (EERS) approach to energy sales growth by implementing the study provision included in the Energy Policy Act 2005 and developing a national policy;*

    - *Promote a more stringent national building code standard by upgrading to the latest International Energy Conservation Code, learning from leading voluntary building standards initiatives to incorporate new energy efficient technologies into design and construction practices. In the interim, CECA recommends that State and local governments adopt the 2006 International Energy Conservation Code, maintained by the International Code Council, as the minimum standard for new and renovated residential and commercial buildings.*

    - *Rapidly complete DOE's current list of pending appliance efficiency standards and develop and enforce the 16 new standards mandated in the Energy Policy Act of 2005.*

    - *Fully fund increases in energy efficiency RDD&D programs as authorized in the Energy Policy Act of 2005.*

- *Extend consumer, business, and manufacturer energy efficiency tax credits provided in the Energy Policy Act of 2005 beyond the current expiration date to 2010, subject to reauthorization at such point.*

- *Provide full funding for energy efficiency consumer education initiatives authorized in the Energy Policy Act of 2005.*

23. *CECA recommends that States and State Public Utility Commissions implement the following measures to support energy efficiency:*

    - *Create ratemaking mechanisms that allow utilities to recover the costs of serving consumers, regardless of the volume of electricity sales.*

    - *Require distribution utilities operating in markets with retail competition to procure energy efficiency and renewable energy resources when conducting procurements for default generation service.*

    - *Create specific energy savings targets for utilities as a percentage of either forecast load growth or sales.*

## 5.5 Coordination and Funding of Research and Development Efforts

### *CECA Forum Conclusions on Research and Development Efforts*

The CECA Forum believes that a national commitment to energy research and development is needed to ensure that nation's energy needs are met in environmentally responsible, affordable, reliable, and secure ways. Supporting this research effort is a major responsibility of government. R&D efforts can result in improved environmental performance of fossil energy fuels, reduced capital costs of renewable technologies, and development of such processes as hydrogen production from nuclear facilities. Research and development can improve energy efficiency technologies resulting in reduced overall energy consumption. Developing alternative uses of coal through R&D activities can help mitigate rising oil and natural gas prices. Developing alternative approaches to managing the nuclear fuel cycle through R&D will allow nuclear power to play a more robust role as a GHG emissions-free resource. Developing breakthrough technologies through R&D can make renewable energy a significant portion of the nation's future energy portfolio. These opportunities and others are discussed more fully in the CECA Forum's conclusions and recommendations on specific fuels and technologies in this chapter.

To meet the nation's energy needs, a research pipeline is required for new energy technologies that addresses not only near-term deployment issues, but also next generation technologies and technologies for the generations that follow. To that end, CECA supports many of the related incentives in the Energy Policy Act of 2005. CECA calls on policymakers to make energy R&D a national priority and to commit the significant funds necessary to ensure that the stationary energy needs of the nation's consumers are met in environmentally responsible, affordable, reliable, and secure ways.

### *CECA Forum Recommendations on Research and Development Efforts*

24. *CECA recommends continuation of the incentive provisions of the Energy Policy Act of 2005 for production tax credits and investment tax credits, Clean Energy Bonds, and loan guarantees as appropriate to support market adoption of clean energy technologies, including clean coal technologies, nuclear energy, wind, solar, hydropower, and other renewable resources, and energy efficiency. CECA further recommends that Congress extend the duration of these incentives to allow predictability when planning these investments.*

25. *CECA believes the challenges of meeting the nation's future energy requirements in accordance with the National Consumer Priorities of affordability, environmental protection, reliability, and security require a major national commitment to research and development into a broad array of energy fuels, energy efficiency mechanisms, and energy technologies. CECA therefore recommends that Congress make funding of such programs a national priority. This national commitment should be targeted to research and development programs that:*

    - *Lead to the next generation of advanced clean energy technologies;*

    - *Improve the environmental and efficiency performance of existing energy systems;*

    - *Expand the potential applications for existing technologies to address other critical energy needs.*

    - *To overcome historic funding deficiencies for energy research and development, CECA further recommends that Congress explore alternative means of funding research and development to allow for significantly larger research investments and more predictability in undertaking multi-year research initiatives.*

## 5.6 Upgrading the Nation's Energy Systems Infrastructure

### *CECA Forum Conclusions on Upgrading the Nation's Energy Systems Infrastructure*

Ensuring that the nation's future energy needs can be met in ways that are consistent with the National Consumer Priorities involves more than improving the energy fuels and technologies themselves. It also requires improvements to the infrastructure upon which the diverse portfolio of fuels relies. Much of the energy sector is heavily dependent upon the transportation sector and projected constraints in that sector will become impediments to meeting the nation's energy goals. In addition to physical improvements to the energy infrastructure, there is a critical need to develop the skills required to design, build and operate the complex energy systems. Finally, an area of growing and vital concern is the interdependency of the nation's water supply and its energy system needs.

As the nation prepares for increased energy demand, a key consideration must be the ability of the infrastructure to move that energy from its source to its market. CECA has undertaken a major analysis of the nation's transmission system and supports the need for the nation's energy planners to identify and plan for the proper expansion of the system. That support is inherent in many of the recommendations contained throughout.

### Energy Transportation via Rail and Barge

Rail and barge constitute the number one and two transport means for delivering the nation's coal to the electrical generator. Given the location of the coal relative to the location of the nation's rail system, 30 percent of total coal-generated capacity comes from power plants that are served by a single railroad for delivery. This non-competitive situation may result in higher charges for coal than if multiple transportation providers were available. The added cost of transportation may ultimately increase the price of delivered electricity to the consumer.

Demand for rail freight is increasing due to the state of the economy and the fuel efficiency of railroads relative to trucking. Railroads must invest significant capital in order to remove bottlenecks and improve throughput to meet rapidly growing demand. Legislation is expected to be introduced soon to provide railroads with investment tax credits for expansion projects.

The nation's barge system is dependent upon a system of locks and dams that allow low-cost shipping of bulk materials, including coal. The system of waterways is in need of repair and improvement. Federal monies have not been appropriated nor have other available monies been used.

### Modernizing the Nation's Transmission System

Owners and investors in the transmission system make investment decisions based on the risk of a project being completed in a timely manner and operated profitably. A study published by CECA in 2005 on the nation's transmission needs, *Keeping the Power Flowing: Ensuring a Strong Transmission System to Support Consumer Needs for Cost-Effectiveness, Security and Reliability*,[3] noted that one of the greatest risks is regulatory uncertainty. The owners, operators, and investors need to predict accurately the outcome of regulatory processes within acceptable tolerances. Stated another way, the "rules of the road" should be designed to lead to predictable results that are acceptable to owners, operators and investors.

### Energy Systems Workforce Issues

Lack of a skilled workforce is also a constraint to meeting the nation's future energy needs. The existing workforce is aging and in short supply. Exacerbating this situation is the low number of students entering into engineering and other fields compared to the manpower necessary for fulfilling the nation's energy demands. While enrollments in nuclear technology departments have been steadily increasing in recent years, the pace of graduating engineers is still outstripped by the anticipated need.

### *CECA Forum Recommendations on Upgrading the Nation's Energy Systems Infrastructure*

26. *CECA recommends that Congress encourage reinvestment of capital for expansion of the railroad system by means of incentives such as investment tax credits, and increased investment at the federal level for waterway enhancement. Congress and the Surface Transportation Board (STB) should encourage railroads to provide more reliable service to their customers, and promote increased competition in the railroad industry while ensuring railroads earn sufficient revenues. Finally, Congress should encourage the STB to develop a fair and balanced means of determining reasonable railroad rates to captive shippers, which could include an alternative to the stand-alone cost (SAC) methodology currently used in most railroad rate cases.*

27. *CECA recommends that, given the significance of the nation's navigable waterways to the provision of low-*

3 CECA, *Keeping the Power Flowing: Ensuring a Strong Transmission System to Support Consumer Needs for Cost-Effectiveness, Security and Reliability*, January 2005.

*cost energy to America's consumers, Congress place a priority on the funding, construction, and maintenance of navigable waterways as critical energy infrastructure.*

28. *CECA recommends that FERC and State regulators encourage investment necessary to ensure that the transmission system is robust and can adequately and reliably provide the backbone needed for future fuel supply siting decisions.*

29. *CECA recommends that the Federal government address the infrastructure requirements of the energy industry. These requirements include both manpower needs and materials needs. CECA recommends the establishment of multi-agency programs to support technical training programs as well as address limitations in current materials fabrication and manufacturing capability. The technical training programs are needed to build and maintain talent in basic science education, advanced engineering disciplines, and the skilled trades necessary to design, construct, operate, and maintain such complex energy facilities as nuclear power plants.*

## 5.7 Interdependencies of Energy System Needs and Water Availability

In the majority of fuel supply technologies, water is an essential component, either to assist in combustion, aid in onsite storage, or provide coolant for other parts of the process. However, inadequate water supply is forecasted to become a major constraint to meeting the nation's stationary energy needs. Energy production is a major user of water – in coal generation and nuclear power operations, mining, hydroelectric power, and the development of coal bed methane.

### CECA Forum Conclusions on Interdependencies of Energy System Needs and Water Availability

Currently, issues related to water availability and energy systems that require the use of water are resolved on a case-by-case basis with little understanding of the wider implications in other sectors or regions. A national plan is needed to address the water scarcity issue so that competition for critical water resources, across multiple sectors, including agriculture, and within the energy sector, does not result in failure to supply the nation's energy needs.

### CECA Forum Recommendations on Interdependencies of Energy System Needs and Water Availability

30. *CECA recommends the expedited funding of the DOE Water/Energy Office mandated by Congress in the Energy Policy Act of 2005 to coordinate energy/water related research and development, and serve as a focal point for interagency issues, working with the national laboratories, the U.S. Department of Interior, and other relevant Federal, Regional, and State agencies to ensure coordinated planning for energy and water needs.*

## 5.8 U.S. Climate Policy

### CECA Forum Conclusions on U.S. Climate Policy

The diversity of membership in the CECA Fuels and Technologies Forum is reflected clearly in the diversity of views that exist regarding what federal policies best facilitate steady progress in reducing greenhouse gas (GHG) emissions. Ironically, there is little or no difference in individual visions as to the appropriate long-term goal, i.e., the achievement of very low if not near-zero net emissions. Nor is there disagreement regarding the pivotal role that advanced technologies and mitigation opportunities can play in making dramatic and continuous reductions a reality. Instead, the differences lie in when national policies are necessary to effect this shared vision and what kinds of policies are needed.

Climate change is a serious global long-term issue, requiring sustained action by all sectors of the economy over many generations by both developed and developing countries. While there are skeptics, scientific opinion, as embodied in the Intergovernmental Panel on Climate Change (IPCC), believes that there is now a well-established link between increasing temperatures and increasing GHG emissions. This discussion focuses on the U.S. stationary source sector – not because it the only area that should be addressed, but because it is the only sector within the scope of the CECA Forum. The CECA Forum recognizes that climate policy must include the transportation sector as well.

CECA believes that differences regarding *how* to address the climate issue in the near term should not overshadow *what* we are trying to achieve. Accordingly, CECA strongly endorses broad, public and private sector policies and initiatives that stimulate investment in new technologies and behaviors that move the nation toward environmentally friendly, cost-effective solutions for addressing the climate change issue.

There are various greenhouse gas regimes at the international (e.g., Kyoto Protocol), Regional (e.g., RGGI), and State levels (e.g., Massachusetts, New Hampshire, Oregon, and

Washington). Individual State agencies have also adopted climate policies (e.g., the California PUC and CalPERS). Congress's most recent attention to climate change is embodied in the Energy Policy Act of 2005. This legislation was enacted shortly after the U.S. and the other G8 nations agreed on a plan of action to slow and, as the science justifies, stop and reverse the growth of GHG emissions. To date, however, there are no mandatory Federal government programs targeted specifically at reducing GHG emissions. Current Federal policy is focused on technology development and voluntary actions and partnerships, both domestic and international.

Many domestic stakeholders and international interests are requesting that policymakers develop further policies sooner rather than later to reduce GHG emissions. The uncertainty about which national policy will or should be implemented to achieve reductions in GHG intensity and emissions in the next 20 years represents an enormous issue to industry. Uncertainty results in lack of investment in new technologies, while certainty would provide opportunities for U.S. industry to invest in new technologies that could be utilized domestically and internationally. In crafting such policy, government should consult with various stakeholders regarding structure and implementation.

Some degree of certainty on future national climate policy is needed to ensure that significant investments required in the energy sector continue to be forthcoming. Whatever additional policies are developed, certain criteria designed to support the consumer's interest should be included. In addition to environmental and affordability criteria, climate policy involves complex issues of national energy security (more or less reliance on fuels from unstable regions), economy and jobs (potential reductions in industries producing significant GHG emissions, coupled with potential increases in industries involved in climate friendly substitutions), and business planning (uncertainty can translate to higher costs). GHG mitigation measures should include energy efficiency, the substitution of new technologies in end-use applications, and development and deployment of technologies to improve the environmental characteristics of each fuel in the nation's fuel's portfolio. The consequent reduction in the use of energy, coupled with cleaner fuels, will reduce GHG emissions intensity and emissions. New policies must take into account economic implications to electric utilities, their customers and society as a whole, as well as the need for energy reliability and environmental improvement.

Climate policy is an important issue to energy consumers as it is central to environmental protection, sustainable economic development, and affordable and reliable power in the future. A number of conclusions can be drawn from a consumer perspective:

- CECA believes the climate problem is serious and GHG emissions must be reduced.
- CECA believes it is clear that much can be accomplished now at an acceptable cost. States have already begun to take measures that they believe are cost-effective and in the consumer interest and such measures must encouraged.
- CECA believes that while participation by developing countries is important to a comprehensive strategy for reducing greenhouse gas emissions, the best way to encourage international cooperation is for the U.S. to take a leadership position and CECA encourages such a major leadership role by the U.S.
- CECA believes the absence of a long-term comprehensive framework will increase costs to consumers. These costs will only increase as time passes, given the almost universally shared view that a carbon-constraint program will come into being. Therefore, it is not in the consumer's interest for policymakers to delay serious consideration of the design of a national policy.

### CECA Forum Recommendations on U.S. Climate Policy

31. *CECA recommends robust implementation of the climate and energy technology-related provisions of the Energy Policy Act of 2005, particularly Titles XVI and XVII and other related provisions, such as clean coal technology, nuclear energy, energy efficiency measures, and renewable energy resources, including hydropower, that will facilitate a broad portfolio of diversified generation resources.*

32. *CECA recommends that policymakers put a priority on the development of low- and zero-emissions technologies through accelerated research, development, demonstration, and deployment programs. Public-private partnerships that manage the costs and benefits of these RDD&D programs should be combined with appropriate incentives available to all segments of the industry to advance technologies into the marketplace.*

33. *CECA recommends that policymakers recognize the significant roles that energy efficiency and the utilization of emissions-reducing technologies in end-use applications can play in reducing GHG emissions and thus include appropriate incentives to utilities to encourage their active involvement in such low-cost means of reducing emissions intensity and emissions.*

*34. CECA recommends that policymakers recognize the national energy security, environmental, and economic dimensions of this issue, develop and apply economic modeling practices to climate policy proposals, and provide incentives for development and use of energy from domestic, GHG-friendly technologies.*

# Fueling the Future:
## Better Ways to Use America's Fuel Options

# Part Two

Chapter Six: A Comprehensive Analysis of the Costs and Benefits of the Nation's Fuel Options

Chapter Seven: A Brief History of Energy and Environmental Policies in the United States 1901-2005

# Fueling the Future:
## Better Ways to Use America's Fuel Options

## CHAPTER SIX:

# A Comprehensive Analysis of the Costs and Benefits of the Nation's Fuel Options

### 6.0 Building for the Future: Costs and Benefits of Fuels

This chapter provides CECA's comprehensive analysis of all fuels used to meet stationary energy needs and the technologies associated with them. This is the first such analysis presenting the opportunities and barriers of each fuel in a single document and it should be enormously valuable for policymakers and planners.

Understanding the costs and benefits of each fuel will better enable policies to be developed which optimize the benefits and reduce the negative characteristics of each fuel. Important information is provided on each of the major energy fuels/technologies available for deployment in the next 20 years. For each fuel, CECA provides information on the current usage of that fuel, technologies and trends in those technologies, both price (either in terms of commodity pricing or price of delivered electricity) and costs (capital costs and operating/maintenance and fuel costs) for creating the energy, regulatory drivers and other benefits and obstacles. The information in this chapter will provide a strong starting point for understanding the complex and innovative proposals confronting Federal, State and local energy officials.

#### *Need for Fundamental Information*

The United States utilizes a variety of energy resources and many different technologies to serve its substantial energy needs. Multiple technologies exist to make use of these energy resources, and each of these technologies creates a unique set of benefits and costs to the consumer. This chapter examines the costs, benefits, and challenges of each fuel as a basis for determining how to best help consumers meet their future energy needs.

The purpose of this chapter is to provide an initial, objective, consumer-centric description of the energy fuels and the technologies currently in place to utilize these fuels. Ultimately, this information can serve as a reference volume on fuel technologies and fuel costs. This chapter also encompasses analysis of energy efficiency since energy efficiency can be analyzed as a fuel resource for meeting future demand growth.

#### *Approach to Developing Data*

The data and information in this chapter are organized around the energy fuels and the major technologies for their use. The information describes each fuel resource, provides an explanation of the technologies that are used to convert each fuel into usable energy, such as combustion technologies for coal or home heating technologies for fuel oil. The technology discussion includes an overview of the pertinent pollution control equipment and a brief overview of near-term technology developments. The technology discussions are designed to educate policymakers about the range of technology options available. This chapter then provides an overview of the price and cost information of each fuel and associated technologies. The most relevant benefits and challenges applicable to each fuel or fuel technology complete each fuel subsection.

#### *Description of Fuel and Technology Costs*

Patterns of energy consumption for stationary applications are quite different from those for transportation purposes. Petroleum constitutes the largest single source of energy fuels consumed in the United States (see Figure 14). Because more than two-thirds of the petroleum consumed in this country is for transportation needs, however, taking transportation out of the picture shows the relative significance of other energy fuels (Figure 15). As described in Chapter Three of this report, coal and natural gas are the largest sources of energy fuels for stationary purposes. Coal and nuclear energy are used primarily in power production, while natural gas is used in residential and commercial heating and cooling, industrial feedstock and process steam, and power production. Although not nearly as dominant in the stationary uses as it is in transportation, petroleum is also consumed in residential and commercial heating, as well as in power production and backup generation. The utilization of petroleum for power production has decreased markedly over time. Nuclear energy and renewable resources make up the remainder of the non-transportation energy fuels.

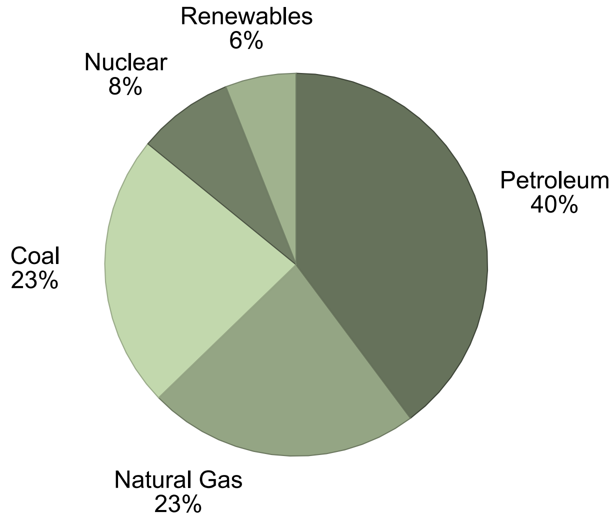
## 6.1 Fuels and Technologies in Context

In the rapidly deregulated energy marketplace, developers, Wall Street, and independent energy producers will be making the majority of decisions about the deployment and implementation of new facilities and the viability of fuels used to run them. This does not mean there is not a role for policymakers – in this chapter, and throughout this report, we have attempted to point out the many issues that will certainly need policymaker attention for the energy markets to run smoothly and provide safe, clean, and affordable energy for consumers.

This chapter contains a wealth of information on all of the major fuels and technologies that will play prominent roles in the next 20 years. However, it is also important for policymakers to note that it is almost certain that surprises will crop up. CECA can be fairly certain that new breakthroughs in energy technologies will continue over the next 20 years, some of which may add incremental improvements to the current system, while others may be transformative. With this in mind, it is important for policymakers to understand the current state of fuel-utilizing technologies so that the U.S. can maintain a flexible system that allows for positive change when new technologies arrive.

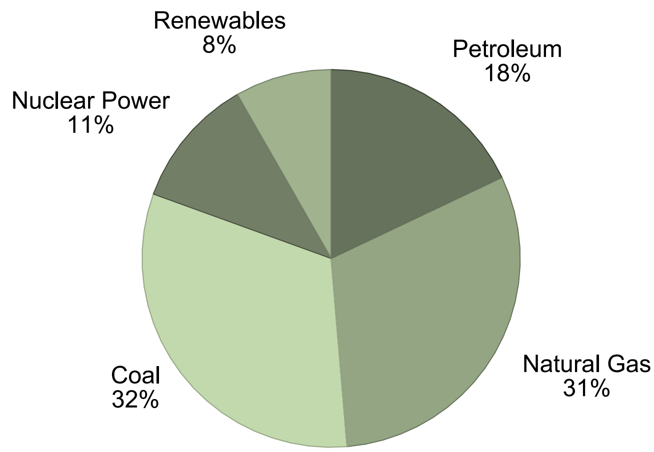
There are a few key elements CECA hopes policymakers will take out of this chapter: while descriptions of the technologies are sophisticated and heavily detailed, some common themes come through. First, the lead time for construction of new power plants ranges from two to eight years – not including permitting process, raising capital, and other up-front tasks – meaning that the industry needs to make assumptions about energy load, demographics, and distribution networks that may or may not still be valid by the time the facility is completed. Secondly, once the facility is completed, the lifespan for a typical power plant is 40 to 50 years. Again, this means that assumptions made today need to be weighed against a variety of factors that could influence the viability of the facility for decades into the future. Ultimately, as the chapter demonstrates, the only resources that are relatively immune to the risks of change over the next decades are energy efficiency measures, since they do not rely on a fuel resource to be successful. CECA has purposely highlighted energy efficiency issues throughout this report precisely because of this point.

**Figure 14: Total Energy by Fuel**




*Source:* EIA, *Annual Energy Outlook 2005*

**Figure 15: Total Stationary Energy by Fuel Type**




*Source:* EIA, *Annual Energy Outlook 2005*

Third, this chapter shows definite trends in the technologies now being developed to utilize available fuels options. For much of the 20th Century, the design and construction of power plants did not change much. Today, and for the foreseeable future, environmental and fuel scarcity factors will play stronger roles in pushing the industry to develop cleaner and more efficient technologies. Clean coal technologies and improving designs for renewables are excellent examples of this trend. Another trend worth noting is the gradual blurring of the traditional categories of electricity and heating. Once these two industries were almost completely separate, but distributed energy and combined heat and power technologies are penetrating the marketplace at a strong pace. CECA recognized this trend in the late 1990s and concluded that, because of the tremendous benefits in terms of fuel efficiency, "the time has come for a concerted effort to move towards greater reliance on DE to meet our burgeoning energy needs."[1] Since then the U.S. has

1 CECA, *Distributed Energy: Towards a 21st Century Infrastructure*, July 2001.

seen a strong growth in these technologies demonstrating that heating and the production of electricity are no longer independent silos that should be thought of separately.

## 6.2 Fossil Fuels

The major fossil fuels used for stationary purposes are coal, natural gas, and petroleum products. A detailed discussion of each of the fossil fuels is presented in this section.

### *Coal*

Coal represents an abundant domestic source of fuel, with U.S. recoverable reserves estimated at over 267 billion tons, with a demonstrated reserve base at nearly 500 billion tons.[2] Under current usage, the U.S. is estimated to have more than 250 years of proven reserves. Coal is responsible for slightly more than half of all electricity production in the U.S., and electricity production, in turn, constitutes nearly 92 percent of coal consumption in the U.S. High value coal is also used for metallurgic purposes such as coke for steel production.

### Fuel Resource and Technology

The properties and composition of coal can vary widely, depending on the conditions of decomposition and the geologic age of the coal deposit. At the most basic level, coal generally is classified (or ranked) by moisture content and/or carbon content. Most of the world's coal is bituminous or lower-rank. Anthracite coal accounts for only about one percent of the world's coal. In general, the energy content is proportional to the carbon content, and inversely proportional to oxygen or moisture content. Energy content, or heating value, is measured by BTUs per pound of coal. Table 10 provides key characteristics of the various coals.

The locations of major U.S. coal deposits are shown in Figure 16 by coal ranks. The bituminous regions of Northern and Central Appalachia provide low-sulfur bituminous coal for metallurgical coke and electricity. Traditionally, the bituminous coal from Illinois and elsewhere in the Midwest was used for the generation of power. However, the demand for this high-sulfur coal for electricity generation has decreased, replaced by the low-sulfur, sub-bituminous coal from the Western U.S., such as the Powder River Basin and Appalachia (Figure 17). Coal production in the U.S. increased in 2004 by 3.7 percent to 1.11 billion short tons.[3] Coal consumption increased in the electric power sector by 1.0 percent, and both exports and imports of coal increased.

### Combustion Technologies

***Pulverized coal combustion (PC)*** is the predominant commercial technology for generating electricity from coal. Historically, combustion occurred at atmospheric pressure using sub-critical steam. More recently, commercial processes became available that use super-critical steam that results in higher rates of energy efficiency (38 to 40 percent vs. 36 to 38 percent for sub-critical). Supercritical plants operate at higher pressures and temperatures and have higher capital costs and additional risk. Sub-critical pulverized coal remains the predominant commercial choice in the U.S.: only four of the 87 new pulverized coal plants currently under development in the U.S. plan to use super-critical technology.

***Integrated gasification combined cycle (IGCC)*** plants convert coal into a gas using a gasifier. The synthesis gas or syngas is predominantly a mixture of hydrogen and carbon monoxide, which is used in place of natural gas in a conventional combined-cycle plant, resulting in low levels of pollution and high levels of system efficiency. Emissions from IGCC plants of sulfur dioxide ($SO_2$) and nitrogen oxides (NOx) are less than one-tenth of those allowed under limits in the U.S. New Source Performance Standards for coal-fired generators.4 The efficiency level of IGCC plants can be as high as 43 percent. Most existing IGCC plants are commercial in terms of scale and operability. Fifteen additional IGCC plants are currently at various stages of consideration in the U.S.

***Fluidized bed combustion (FBC)*** plants blow air through the floor of the boiler, which suspends or "fluidizes" coal particles mixed with a sorbent such as limestone. The sorbent facilitates the capture of $SO_2$, and can remove between 93-95 percent of the $SO_2$. Atmospheric fluidized bed combustion plants operate at atmospheric pressure, and NOx generation is minimized because of lower combustion temperatures

**Table 10. Characteristics of the Various Coals**

| Rank | Carbon Content | Heating Value | Comments |
|---|---|---|---|
| Anthracite | 95% | ~14,000 BTU/lb. | Smallest reserve, heating only |
| Bituminous | 75-88% | ~12,500 BTU/lb | Largest reserve, power and metallurgical coke |
| Sub-bituminous | 65-75% | ~9,000 BTU/lb | Large range for heating value |
| Lignite | 25-50% | ~6,500 BTU/lb | Brown coal, steam power only |

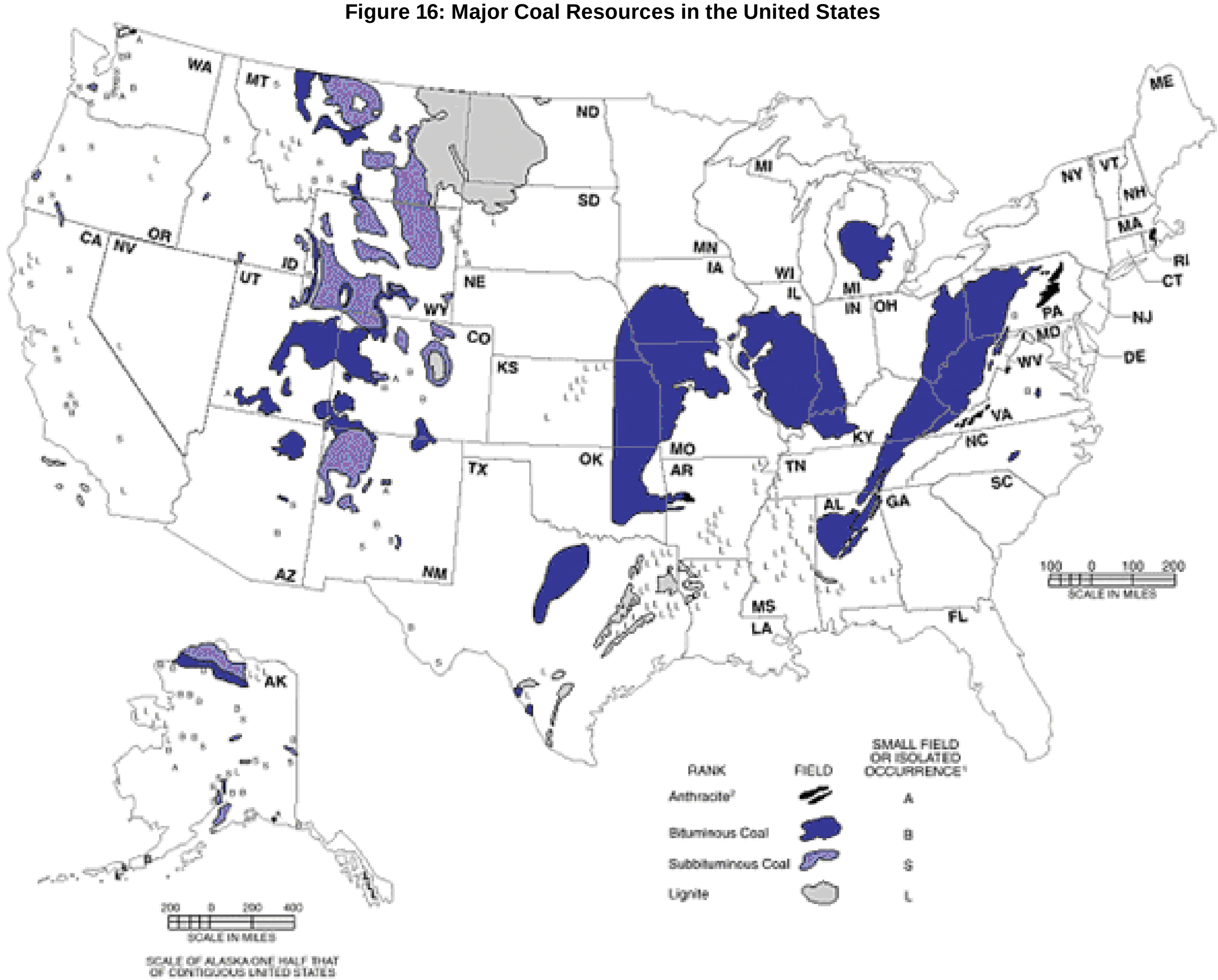
*Source:* Wendell Wiser, *Energy Resources*, 2000

2 EIA, *Annual Energy Outlook 2005*.

3 EIA, *Annual Energy Review 2004*, August 2005.

4 Code of Federal Regulations Title 40 part 60 [40CFR60], "Standards of Performance for New Stationary Sources," September 1997.

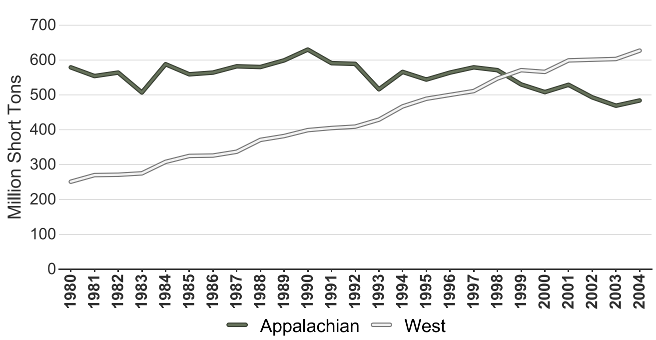
**Figure 16: Major Coal Resources in the United States**




*Source:* EIA, *Coal Reserves Data 2005*

(815° C to 875° C) than in conventional pulverized coal plants with similar efficiencies. Pressurized fluidized bed combustion plants operate at elevated pressures are typically more compact and offer the potential for higher levels of efficiency, reduced operating costs, and lower amounts of waste than the atmospheric design. The niche for fluidized bed combustion is in smaller plants that use low-sulfur and/or high-ash coal (for example, coal waste) and in re-powering aging pulverized coal plants. Currently, 12 of the 114 coal-fired power plants under development in the U.S. plan to use fluidized bed combustion technology.

**Figure 17: Coal Production Trends by Region**




*Source:* EIA, *Annual Energy Outlook 2005*

## Pollution Control Technologies

Sulfur dioxide, $SO_2$, which is produced from sulfur impurities in the coal (high-sulfur coal can contain as much as five percent sulfur), is a pollutant of concern because of its contribution to acid rain and because it is a precursor to fine particulate formation (PM2.5). Flue gas desulfurization technology is used to reduce $SO_2$ emissions. In almost all such systems, $SO_2$, which is acidic in nature, is removed from the flue gas by reaction with a suitable alkaline substance to produce a solid sulfite or sulfate product. The most commonly deployed technology is the limestone/gypsum process, which is deployed worldwide with more than 400 units and a total installed capacity well in excess of 150 GW. Overall, this process usually offers the lowest lifetime costs for a large plant, with a projected long residual lifetime, high load factor, and use of moderate-sulfur-content fuel. Pre-combustion processes, such as coal beneficiation and coal washing, remove sulfur from coal prior to combustion, thereby reducing $SO_2$ emissions. Pre-combustion processes can be an enhancement or an alternative to post-combustion technologies.

Nitrous oxides, NOx, are of concern for a variety of reasons, including acid rain, ozone, and secondary PM2.5 formation. Although efforts to control the combustion temperature and environment are the first choice in NOx control, ever more stringent regulations have required many facilities to install flue gas NOx removal systems. The primary NOx flue gas removal technology is selective catalytic reduction (SCR) systems, which are highly effective at cutting emissions of NOx from power-generating equipment. SCR systems use catalysts to promote a reaction between flue gas NOx and a reagent—typically ammonia—that is injected into the flue gas stream. The catalysts "selectively" convert NOx into nitrogen and water, thereby reducing NOx emissions by around 85-90 percent. Typically, SCR systems consist of porous ceramic, honeycomb substrates that have been coated with a catalyst.

Flue gas cleaning in pulverized coal plants is conducted on the flue gas as it exits the boiler. Flue gas represents a significant increase in the volume of gas, and at atmospheric pressure, requiring much larger, more expensive equipment. Furthermore, the concentration of the pollutants to be removed (NOx and $SO_2$) is quite dilute; efficient removal of dilute pollutants requires more complicated (and expensive) equipment than a concentrated pollutant does.

## Prices and Costs

Prices of coal are less transparent than prices for natural gas and oil, due to relatively low liquidity, limited futures markets, and a history of confidential bilateral agreements. The commodity charge for coal per MMBTU is based largely on its quality, determined in large part by the sulfur content, and by heating value. Transportation costs, or distance from the coal mine to the power plant, contribute a significant part of the ultimate cost of the commodity to the utility, which is the reason that mine mouth prices are not the only values tracked.

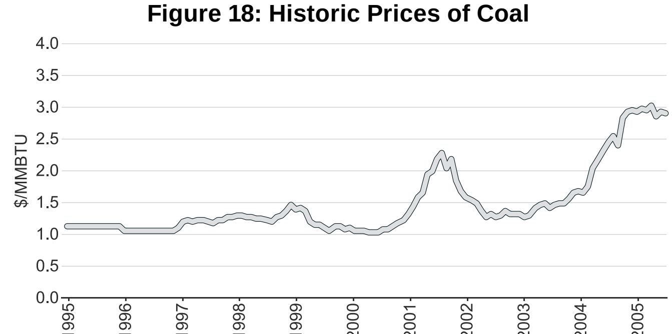
Spot price increases have outpaced the average delivered price increases in the consuming sectors, in part because coal deliveries to utilities usually are under long-term contracts. From the 1990s through 2000, the price of coal showed a steady decline in terms of constant dollars in all regions. This is somewhat surprising, considering the continued growth in coal demand and the regional shift in production as the West gained market share. The overriding factor appears to have been the movement towards natural gas as most of the new electric generating units built in this period were natural gas-fired.

Beginning in 2001, prices and price volatility for coal have increased (Figure 18). Increases in the price of bituminous coal in the East have been caused by several factors. These include high demand because of high prices of natural gas, ongoing environmental and permitting problems in Eastern coal fields, closure of many marginal mines, and resurgence in exports due to increased global demand.[5] In response, bituminous coal prices in the West also have increased, though prices of coal from the Powder River Basin have been relatively stable. Although EIA forecasts relatively flat prices beyond 2005, none of the factors that underlie the recent increases in coal prices appears likely to change soon. However, various production and consumption trends, in the U.S. and abroad, point to a marked increase in demand. Many industry observers believe that the current increase in prices of coal may be sustained through the decade, with the most bullish observers seeing price increases through 2015.[6]

Prices of energy commodities usually are more volatile than those of non-energy commodities due to the relative inability of consumers to alter consumption or substitute in the near term. This generalization is true for coal markets, as electricity producers are constrained in their ability to reduce coal consumption in response to higher prices. High price volatility is based on the prospects for continued uncertainty in coal markets, as well as events such as transportation disruptions, which affect the activity of the market in the short term. Therefore, coal markets of the future are likely to be higher-priced and more volatile than in the past.

Under current environmental regulation, sub-critical pulverized coal plants are the most economical coal-fired technology for large-scale base load applications. As reflected by the current activity in the U.S. market, the increased efficiency of super-critical pulverized coal does not appear to come at a price and risk profile that makes it attractive. Interest in IGCC technology is driven in large part by the

**Figure 18: Historic Prices of Coal**




*Source:* EIA, *Annual Energy Outlook 2005*

5 Casey J. Kaptur, "Trends in U.S. Domestic Coal Markets: Are Higher Prices and Higher Price Volatility Here to Stay?" *Pinkcock Perspectives*, No. 58, September 2004.
6 *Ibid*.

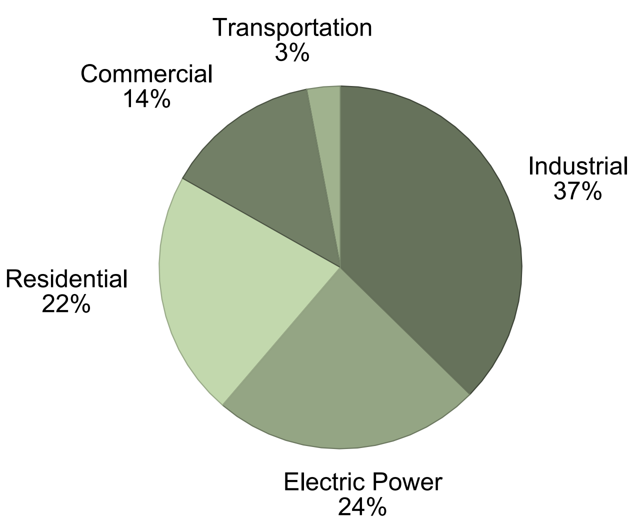
potential cost of meeting new environmental regulations and the potential for $CO_2$ capture and storage. Fluidized bed combustion has a niche for such low-quality coals as high-sulfur coal and waste coal in smaller-scale plants or in re-powering aging pulverized coal plants.

## Regulatory Drivers

The major external drivers for coal and coal technology are environmental. In March 2005, the EPA issued the Clean Air Interstate Rule (CAIR), which imposes caps on NOx and $SO_2$ emissions within the Eastern U.S. CAIR will be implemented in two stages, with ultimate reductions by 2015 of 61 percent for NOx and 70 percent for $SO_2$, with respect to 2003.[7] The main human health driver for CAIR is the reduction of PM2.5, which is produced in the atmosphere by the reaction of $SO_2$ with ammonia. Also in March 2005, the Clean Air Mercury Rule (CAMR or Mercury Rule) was issued by EPA with the design to cap permanently and reduce emissions of mercury. For the first phase of reduction, by meeting CAIR, no further action is required to meet the Mercury Rule, yet will result in a reduction from an estimated 49 to 38 tons/year from installation of CAIR-inspired technology. Phase 2, which takes effect in 2018, is a reduction to 15 tons/year, independent of any other regulation. The Mercury Rule allows States to set up trading regimes under the cap as a method to achieve lowest cost compliance. Mercury budgets are on a state-by-state basis, rather than a national basis. Finally, in June 2005, EPA finalized the Best Available Retrofit Technology amendments to the 1999 Regional Haze rule.

The Energy Policy Act of 2005 contained a number of provisions relating to coal, including a coal title, Title IV. While the Act relaxes some regulatory restrictions in terms of leases and mining, the majority of the Act's provisions are focused on providing incentives for clean coal technologies. The effect of these new regulations is that existing and new coal plants will have to install more sophisticated pollution control equipment, increasing the relative cost of pulverized coal with respect to IGCC and fluidized bed combustion. These new rules also represent a cost disadvantage for coal with respect to natural gas and other cleaner fuels and power sources.

**Figure 19: Natural Gas Consumption by Sector**




*Source:* EIA, *Annual Energy Outlook 2005*

### *Natural Gas*

Within the U.S., the consumption of natural gas represents 31 percent of total energy consumed for stationary purposes. Residential and commercial uses combined—primarily heating—represent the largest applications of natural gas (36 percent, see Figure 19). The use of natural gas by industry, both as a feedstock for chemical and other basic commodities and for heating and cooling is the second-largest application (37 percent). The generation of electricity currently represents one-quarter of natural gas consumption in the U.S.

## Fuel Resource and Technology

Russia, Iran, and Qatar together hold more than 58 percent of the global proven reserves of natural gas, while the U.S. holds just over three percent of proven reserves.[8] Table 11 presents estimates of natural gas in the U.S. Canada and Mexico, both of which are connected to the U.S. system of natural gas pipelines, hold proven reserves of one percent and 0.25 percent, respectively. The U.S. accounted for 20 percent of the global production of natural gas in 2003.[9] U.S. domestic production met 85 percent of domestic demand in 2003, with the remainder coming from Canada and imports of liquefied natural gas (LNG) (LNG was less than three percent.). The U.S. consumed 23 percent of the total global consumption of natural gas in 2003.[10]

To have the ability to transport natural gas economically over long distances in which pipelines are not available, the gas must be liquefied. Liquefaction plants are constructed near ports so that natural gas can be liquefied using refrigeration and loaded onto specially designed LNG tankers for transport. Once at their destination, the LNG is offloaded, turned back into a gas at a re-gasification facility, and routed into the natural gas pipeline for transport to the consumer. Imports of LNG more than doubled between 2002 and 2003, with LNG accounting for 12 percent of imports of all natural gas.[11] A number of proposals to expand the capacity

7 See http://epa.gov/cair.

8 EIA data tables, "Existing Electric Generating Units in the United States, 2003 and 2004."
9 CEDIGAZ First Estimates, "The 2003 Natural Gas Year in Review," 2003.
10 EIA, "Dry Natural Gas Consumption: Selected Countries and Years, 1980-2003."
11 EIA, "*Natural Gas Annual 2004*," December 2005.

**Table 11. Mean Estimates of Technically Recoverable Oil and Gas Resources**

| | Crude Oil * (bbls) | Natural Gas (dry) (Tcf) | Natural Gas liquids (bbls) |
|---|---|---|---|
| **Undiscovered Conventionally Reservoired Fields** | | | |
| Alaska | 33.33 | 251.94 | 1.15 |
| Lower 48 States | 71.72 | 429.98 | 6.90 |
| **Total** | 105.05 | 681.92 | 8.05 |
| **Ultimately Recoverable Appreciation in Discovered Fields** | | | |
| **Total** | 67.70 | 390.00 | 13.40 |
| **Continuous Type Deposits** | | | |
| Non-coal bed | 2.07 | 308.80 | 2.12 |
| Coal bed | - | 49.91 | - |
| **Total** | 2.07 | 358.71 | 2.12 |
| **U.S. Technically Recoverable Resources (all sources)** | | | |
| **Total** | 174.82 | 1,460.63 | 23.57 |
| Percentage Federal | 60.0% | 52.4% | 34.7% |
| *Proven reserves are *not* included in these estimates. | | | |

*Source:* EIA, *Technically Recoverable Crude Oil, Natural Gas, and Natural Gas Liquids: Resource Estimates 2004*, at www.eia.doe.gov/pub/oil_gas/natural_gas, Accessed March 7, 2006.

of existing re-gasification facilities and to site and construct new LNG facilities are under consideration. Several of these propose siting the re-gasification facility outside the U.S. and importing the natural gas in gaseous form into the U.S. Other proposals for re-gasification plants have had difficulty obtaining siting approval.

## Technologies

Electricity is generated from natural gas using four primary technologies: (1) simple cycle gas turbine (SCGT) often called a combustion turbine (CT); (2) combined cycle gas turbine (CCGT); (3) gas-fired boiler steam plant; and (4) reciprocating engine. The **simple cycle** plant typically consists of one or more turbines and generator sets (genset). Natural gas is combusted and the hot gases are passed to the turbine, at which point they expand to drive the generator and compressor. About 30 percent of electricity produced from natural gas can be attributed to simple cycle. A **combined cycle gas turbine** plant typically consists of the same turbine genset(s), but the waste heat is recovered in one or more heat recovery steam generators (HRSGs). The steam generated from the HRSG powers a steam turbine that drives a generator, which creates additional electricity and increases the efficiency of the overall plant. About 40 percent of electricity produced from natural gas can be attributed to combined cycle gas turbines.[12] A **gas-fired boiler steam plant** is equivalent to the steam plant technology described in the previous section for use with coal, except that the boiler is fired with natural gas. About 30 percent of electricity produced from natural gas can be attributed to natural gas–fired steam plants. **Reciprocating engines** are used primarily for smaller peaker plants, standby capacity, or facilities, and make up less than one percent of capacity from natural gas–fired plants in the U.S.

The industrial sector uses gas-fired boiler steam plants for process steam in a configuration similar to that described for the power generation sector. Residential heating and hot water systems are the furnaces and boilers found in many buildings today. Forced air furnaces deliver heated air (115° F to 120° F) through ducts. The minimum efficiency standard for furnaces sold in the U.S. is 78 percent. Modern natural gas furnaces achieve operating efficiencies as high as 97 percent Annual Fuel Utilization Efficiency (AFUE).[13]

## Pollution Control Technologies

Natural gas-generated electricity has significant advantages over coal- or oil-generated electricity in terms of emissions of $SO_2$, NOx, $CO_2$, CO, and mercury. $SO_2$ and mercury are not significant issues with natural gas combustion because natural gas typically contains little or none of these elements. Most of the attention focuses on the emission of NOx. The average rates of emissions in the U.S. from natural gas-fired generation are 1,135 lbs./MWh of $CO_2$, 0.1 lbs/MWh of $SO_2$, and 0.25 lbs/MWh of NOx.14

Higher combustion temperatures of higher efficiency turbines contribute to increased formation of NOx. Dry Low

12 EIA data tables, "Existing Electric Generating Units in the United States, 2003 and 2004."

13 DOE, *A Consumer's Guide to Energy Efficiency and Renewable Energy*, September 2005.

14 EPA, at www.epa.gov/cleanrgy/emissions.html, Accessed on March 7, 2006.

NOx combustion systems can allow plants to meet even the most stringent regulations on NOx emissions (below nine ppm).15 Dry Low NOx costs are embedded in the simple cycle and combined cycle investment costs. Water or steam injection reduces combustion temperature and formation of NOx, but cannot reduce NOx much below 25 ppm, and can increase operating and maintenance costs. SCR, discussed in the section above on coal, involves the spraying of aqueous ammonium over a catalyst to react with the NOx to form nitrogen and water. This technique is highly effective in removing NOx (below three ppm), but it has a rather high capital cost and ongoing operating and maintenance costs.

## Prices and Costs

Prices of natural gas are driven by consumer demand, production, net imports, oil prices, and inventory levels. Consumer demand for natural gas is highly seasonal and summer and winter months (for cooling and heating) have the highest demand and prices. This additional seasonal natural gas demand is regionally based and is strongly correlated to ambient temperature. The spring and fall seasons, or "shoulder" months, are the time in which natural gas market participants build up inventories in storage facilities.

Prices of natural gas have risen substantially since 2002, having averaged $3.58, $5.43, and $5.92 per million cubic feet (MCF) in 2002, 2003, and 2004, respectively (see Figure 20). Increased imports of LNG and increased usage of non-conventional sources of natural gas are expected to have a dampening effect on the price of natural gas as they come online over the next five to 15 years.

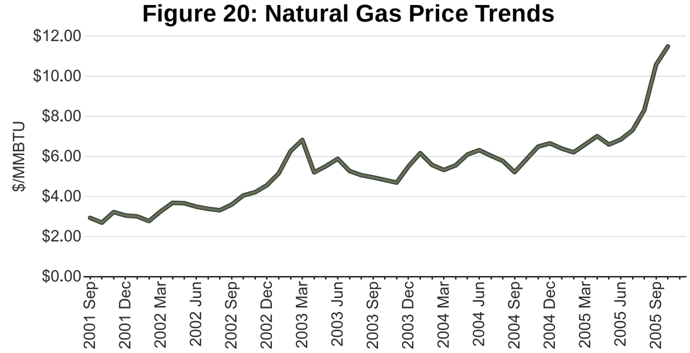
Simple cycle turbines generally are used for addressing peak load, have low capacity factors, and have efficiencies typically in the range of 30 to 35 percent.[16] Based on a sampling of 170 simple cycle plants with an average capacity of 454 MW, actual efficiencies for the past three years average about 30 percent with a five percent capacity factor.[17] Research conducted by Booz Allen Hamilton estimates operating and maintenance costs of simple cycle technology to be $10.99/kWh for fixed and $3.92/kWh for variable costs (excluding fuel).[18] The advantages of simple cycle turbines are simpler design, lower investment cost ($300 to $450/kW installed), faster lead time (one to 1.5 years), low or no water needs, and the ability to be dispatched and ramp up to full power quickly. The disadvantages of simple cycle turbines are their lower efficiency and resulting higher usage of natural gas.

One type of simple cycle advanced design, the aeroderivative design, is particularly well suited for peaking applications. Although aeroderivative turbines typically have higher investment costs ($400 to $450/kW installed) and are limited in size to around 100 MW) in comparison with conventional simple cycle designs, they typically have higher efficiencies (approaching 44 percent), can be ramped up to full power more quickly, can be started and stopped with less wear and tear, and have a more compact design.

Combined cycle plants typically are designed for base load applications with high capacity factors equal to availability, and with efficiencies in the low 50 percent range. In combination with heating and cooling needs for a cogeneration application, the overall efficiency of the cogeneration facility can approach 80 percent. Availability for a typical combined cycle plant is 90 to 95 percent. Based on a sampling of 200 combined cycle plants with an average capacity of 460 MW, however, actual efficiencies for the past three years averaged about 46 percent with a capacity factor of 48 percent.[19] Although the turbine gensets can be started and stopped for peaking or semi-peaking applications, the ramp-up time for the additional generation derived from the HRSG/steam turbine can be significant (one to two hours). This can cause efficiencies to be lowered and can add significantly to operating and maintenance costs. Booz Allen Hamilton estimates operating and maintenance costs for combined-cycle gas turbines to be $1.26/kWh for variable costs (excluding fuel) and $10.00/kWh for fixed costs.[20] The advantages of the combined cycle turbine is higher efficiency and lower usage of natural gas. Disadvantages include higher capital cost ($550 to $600/kW installed); longer lead time (1.5 to 2 years); more complex design with many auxiliary systems; the need for large volumes of high-quality water; and long ramp-up time for starts and stops.

Natural gas-fired boiler steam plant efficiencies are around 34 percent and are designed for base load operation. Capital investment costs are high-$850 to $950/kW installed-yet are lower than the coal-fired steam plants because they

**Figure 20: Natural Gas Price Trends**




*Source:* EIA, *Annual Energy Outlook 2005*

15 M.J. Moore, "NOx Emission Control in Gas Turbines for Combined Cycle Gas Turbine Plant," 1996.

16 Booz Allen Hamilton *Coal-Based Integrated Coal Gasification Combined Cycle Market Penetration Recommendations and Strategies*, 2004.

17 Energy Velocity, EV Power database query of simple cycle combustion turbines with summer capacities between 400-500MW for 2002, June 2005.

18 Independent Expert Review of Fossil Energy Cost and Performance Assumptions in the Electricity Market Module of the National Energy Modeling System, 2004.

19 Energy Velocity, EV Power database query of simple cycle combustion turbines with summer capacities between 400-500MW for 2002, June 2005.

20 Booz Allen Hamilton, *Coal-Based Integrated Coal Gasification Combined Cycle: Market Penetration Recommendations and Strategies*, 2004.

do not have the infrastructure to store and handle coal. Construction lead times are between three and four years. Older natural gas steam plants are frequently dual-fired with oil or coal.

## Benefits and Challenges

From an environmental protection perspective, natural gas has significantly lower emissions of $CO_2$, NOx, $SO_2$, and mercury than any of the other fossil fuels. Both simple cycle and combined cycle turbines have low capital costs and relatively short siting and construction time, and can therefore be brought on line faster and better respond to increasing regional electricity demands.

However, the volatility of natural gas prices and the recent significant increases and supply constraints can hurt consumers in both their heating costs and their electric bill. Furthermore, investors face a higher level of risk in new projects, which translates to delays or deferrals of much needed electric generation capacity. Higher prices have the effect of discouraging the use of gas-fired plants for base-load purposes because of the relatively high marginal cost for gas in the short run, and significant capacity of natural gas-fired electrical generation has been taken out of service. To the extent these investments were made by regulated utilities, the consumer may end up paying for them through a pass-through on their electric bills.

On the supply front, in 2003 the National Petroleum Council concluded that supply from conventional natural gas sources without gains in efficiency would be insufficient to meet projections of the demand for national gas through 2025.[21] The gap would have to be filled by such non-conventional sources as LNG, coal bed methane, tight sands, deeper resources, and the more environmentally sensitive areas in the Rocky Mountain region. The American consumer would thus be faced with increasing dependence on foreign imports of LNG for critical needs and more expensive fuel. Consumer concerns regarding public safety of natural gas and LNG have centered on the safety of pipelines and the siting of LNG port facilities.

## Regulatory Drivers

The deregulation of natural gas began with the Natural Gas Policy Act of 1978, and was completed with the enactment of the Wellhead Decontrol Act of 1989. In 1985, the delivery of natural gas was restructured after FERC developed new regulations for interstate pipelines. In addition, the Department of Transportation's Office of Pipeline Safety is responsible for ensuring the safe operation of the pipeline system in the U.S. State regulatory responsibility is the purview of the State Public Service Commissions.

The Energy Policy Act of 2005 added new provisions that should help in the development and distribution of natural gas. Specifically, the Act clarifies the role of the Federal Energy Regulatory Commission with regard to *onshore* LNG, stating "the Commission shall have the exclusive authority to approve or deny an application for the siting, construction, expansion, or operation of an LNG terminal."[22] (The U.S. Coast Guard is the lead agency for reviewing *off-shore* LNG plant proposals.) The Act also provides clarity on issues such as the extraction of methane hydrates and royalties relating to coastal gas extraction.

### *Oil*

Oil is used for non-transportation purposes as a fuel for residential and commercial heating, for the generation of electricity, and for such non-energy uses as petrochemical production. Petroleum no longer is a significant fuel source (four percent) in the generation of electricity. New oil-fired generation is expected to come on line only as a result of new, industrial, combined heat and power capacity in which process steam is the driver.

Residential heating, which is highly seasonal, constitutes the largest non-transportation use of distillate fuels. Nearly 10 percent of households in the U.S. heat their homes with oil, and nearly 80 percent of the 8.1 million households that heat with oil reside in the Northeastern region. Oil has a small market in new home construction but the industry is attempting to expand the conversion of electric-heated homes to oil and some conversion of natural gas to oil is taking place. In 2001, about 6.6 billion gallons of heating oil were sold across the U.S., with 82 percent sold to consumers in the Northeast, which represents around two percent of annual consumption of crude oil in the U.S.

## Fuel Resource and Technology

The various kinds of fuel oils are obtained by distilling crude oil and then removing the different fractions. Fuel oil Numbers 1 and 2 are referred to as *distillates*, while Numbers 4, 5, and 6 are labeled residual. The higher the number, the heavier the fuel. Diesel fuels, typical home heating oil, and high aromatic content home heating oil all are forms of the broader category No. 2 fuel oil. Residential fuel oil No. 2 generally is a blend of straight-run and catalytically cracked distillates. No. 6 (residual) fuel oil is a thick, syrupy, black, tar-like liquid that consists of a mix of hydrocarbons with high boiling points. Manufacturing companies use it as fuel for steam boilers and power generators. Because of its high

21 National Petroleum Council, "Balancing Natural Gas Policy – Fueling the Demands of a Growing Economy," September 2003.

22 Energy Policy Act of 2005, (Public Law 109-58), Section 251 (e)(1).

viscosity, No. 6 fuel oil is heated to 150° F to 250° F before burning, which reduces demands on the pumps and allows spray nozzles in the burner to turn the oil into a mist for maximum burning efficiency.

Heating oil is produced in either domestic refineries or imported; with imports constituting about 14 to 18 percent of supply. The U.S. is experiencing a decline in the number of domestic refineries for all petroleum products, including heating oil. In 2003, 149 refineries were in operation in the U.S., compared with 324 in operation in 1981, and no new refineries have been built in the U.S. in more than 30 years. However, refineries have enhanced their downstream processing capacity over time, and they are no longer the bottleneck on capacity. Refining capacity has stayed relatively stable at about 16 million barrels per day.[23] Heating oil is, however, imported from Canada, the Virgin Islands, and Venezuela.

As a result of the Northeast heating oil crisis of 2000, Congress authorized the establishment of a Northeast Home Heating Oil Reserve, sized at two million barrels, based on meeting the region's needs for 10 days, the projected time it would take to bring additional supplies from the Gulf of Mexico region. Congress also authorized the creation of the National Oilheat Research Alliance (NORA) and authorized a fee of $0.02 per gallon on purchases of heating oil to fund research and consumer education programs.

Heating oils are intended for use in domestic or commercial space-heating furnaces, or as fuel for small steam or hot water boilers. No. 2 fuel oil is the most commonly used fuel oil in residential heating installations and in many medium-capacity industrial burners.

## Technological Developments

The heating oil industry has identified several thrusts, which include improvements in technology, improvements in fuel quality and performance, and enhancements in equipment and service. The industry expects additional research into additives, performance data, ultra-low-sulfur premium fuels, improved fuel storage systems, and biofuels. In addition, research is likely to focus on reducing installed costs for oil heat systems, low-NOx systems, self-diagnostic and self-adjusting control technologies, and novel combustion techniques.

23 EIA, data tables "U.S. Refining Capacity, Crude Runs, and Utilization Rate, 1973-2002" at www.eia.doe.gov. Accessed March 8, 2006.

## Prices and Costs

Fuel oil is a refined petroleum product. Therefore, it has a direct relationship to world prices of crude oil and supply regions. The average consumer price for heating oil in the Northeast for winter 2003-04 was $1.36 per gallon but increased sharply in 2004-05 to $1.75.[24] The 2005-06 heating season saw another double-digit increase in price. In 2001, distribution and marketing accounted for 46 percent of the cost of heating oil. The cost of crude oil accounted for 42 percent, while the refinery processing accounted for 12 percent.

Seasonality of demand is another factor affecting the variability of prices for heating oil. Unexpected snaps of cold weather can result in sudden surges in demand which impacts the supply in storage. Regional operating costs for transportation and other aspects of the marketing and distribution system can vary as well. Finally, competition in local markets can contribute to disparities in price by region. The oil heat industry is dominated by independent suppliers and dealers; smaller, more rural markets may not attract a large number of competitors.

Considering the wide variety of configurations and the competitive market, a wide margin has to be assumed in projecting the cost of a home heating oil system. In a recent report, the Consumer Energy Council of America estimated the replacement costs for a complete system (for a boiler or furnace) ranging from 2,100 and $5,500.[25]

## Benefits and Challenges

Emission levels from home heating systems appear to be lower than other combustion sources. Emissions of NOx are estimated at less than 0.2 lbs./MMBTU.26 Sulfur is becoming the most significant concern in heating oil. Most heating oil contains 0.25 percent sulfur; however, regulations vary by State and area. The heating oil industry is attempting to move toward an inventory composed of low-sulfur fuel (0.05 percent). This change could result in a reduction of 75 to 80 percent of the $SO_2$ generated by oil heating systems. Many States limit the sulfur content of home heating oil and some are moving toward the more restrictive low-sulfur standard.

Oil heating systems emit both solid particulates and condensable particulates. The other environmental concern with heating oil is potential leakage from storage tanks and spills from barges. The volatility in the price of crude oil and

24 EIA, "Table WF1: Selected Average Consumer Prices and Expenditure for Heating Fuels During the Winter," *Short Term Energy Outlook*, 2004.

25 CECA, *Smart Choices for Consumers: Analysis of the Best Ways to Reduce High Heating Costs*, Washington, DC, November 2005.

26 John Batey, "Advantages of Low Sulfur and Biodiesel Fuel Oil," presentation to the Rhode Island Greenhouse Gas Stakeholders Meeting, 2004.

the capacity of domestic refineries, which together result in tight reserves that could amplify swings in price, can result in significant hardships for consumers who rely on oil for heat.

## Regulatory Drivers

Congress's interest in home heating oil was reflected in legislation that established NORA and the Northeast Home Heating Oil Reserve as well as providing a funding source for future efforts on research and consumer education. The Energy Policy Act of 2005 reiterated Congress's commitment to heating oil by renewing NORA's charter and by including new oil-centered incentives. Clean air rules that specify the content of sulfur in heating oil are the most significant drivers. The industry is responding, however, and is making efforts to secure and market a wider variety of low-sulfur fuels. Carbon concerns could be an issue in the future.

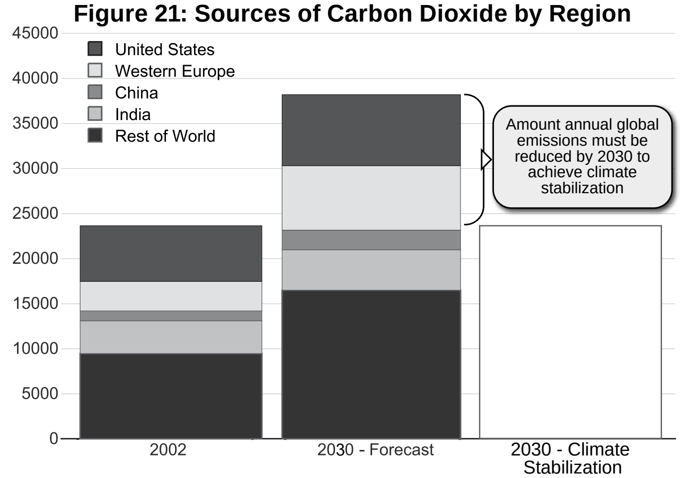
## *Carbon Capture and Storage*

Climate change may impact the use of all fossil fuels in the U.S. over the 20 year timeframe of this analysis. In the past decade, the prospect of climate change as a result of the anthropogenic release of greenhouse gases into the atmosphere has become a matter of increasing concern by policymakers, industry, and the public. Although anthropogenic gases are believed to be largely responsible for climate change, the most significant contributor by volume is $CO_2$ produced by the combustion of fossil fuels. Globally, 40 percent of $CO_2$ emissions are produced by the generation of electric power, with the U.S. as the world's largest emitter of $CO_2$ (see Figure 21).

## Carbon Intensity

Carbon intensity (the amount of $CO_2$ released per unit of electricity produced) increases as one moves from natural gas to oil to coal, primarily because of the increasing carbon-to-hydrogen ratio of the fuel composition. The efficiency of

**Figure 21: Sources of Carbon Dioxide by Region**




*Source:* EIA, *Annual Energy Outlook 2004*

the technology used to generate this power, however, also is a central factor in carbon intensity. Table 12 shows the carbon intensity for a number of fuel/technology combinations.

Research is under way to understand the potential for carbon capture and storage. Simply stated, $CO_2$ can be captured within the process of generating electricity, transported to a geologic repository, and stored, or sequestered, there. Two primary options exist for capturing carbon from fossil fuels: pre-combustion and post-combustion processes, with oxyfuel firing a less mature third option. In pre-combustion processes, the fossil fuel is converted to hydrogen, combined with a shift reaction and $CO_2$ capture based on physical absorption. Post-combustion technology basically adds a $CO_2$ capture system downstream of the power plant to remove $CO_2$ from the flue gas. Amine scrubbing is the best available commercial technology for removing $CO_2$ from flue gas. Typical $CO_2$ removal efficiencies are about 90 percent for both. Once captured, carbon storage options include geologic deposition in oil or gas reservoirs, deep saline aquifers, or coal seams. Although many uncertainties remain and capacity estimates vary significantly, these formations appear to have the potential to store all energy-related $CO_2$ emissions for many years. $CO_2$ storage in oil or gas reservoirs has the potential for economic benefit by increasing the

**Table 12. Power Generation Fuel/Technology Carbon Intensity**

| Fuel | Technology | Efficiency (HHV) | Carbon Intensity (ton $CO_2$/MW-hr. Electricity) |
|---|---|---|---|
| Natural Gas | Combined cycle | 50.2% | 0.35 |
| Natural Gas | Simple cycle | 33.1% | 0.53 |
| Oil | Combined cycle | 49.0% | 0.52 |
| Oil | Simple cycle | 32.0% | 0.79 |
| Coal | Pulverized coal, sub-critical | 36.0% | 0.83 |
| Coal | Pulverized coal, super-critical | 38.0% | 0.79 |
| Coal | IGCC | 40.0% | 0.78 |
| Coal | Atmospheric fluidized bed combustion | 37.0% | 0.85 |
| Coal | Pressurized fluidized bed combustion | 39.9% | 0.79 |

*Source:* R.W. Beck, 2004

production of oil or gas from these fields through enhanced oil recovery (EOR) or enhanced gas recovery (EGR).

## Costs and Risks

Carbon capture and storage requires additional equipment that increases the capital costs and decreases the overall efficiency of power plants. The level of increase in cost and of decrease in efficiency depends on the fuel, the technology used to generate that power, and the approach used to capture the $CO_2$. Table 13 shows the incremental impact on cost and overall efficiency of the process for the relevant combinations of fuel/technology/carbon capture.

The costs associated with transporting and storing the captured $CO_2$ in a geologic repository can vary widely, depending on a number of parameters, including the distance from the repository, the suitability of existing infrastructure (if any), the siting of the repository on-shore or off-shore, and the revenue received for EOR or EGR. The market demand for $CO_2$ for EOR may be such that delivering $CO_2$ to storage becomes a net revenue stream for the power plant. A 2005 study by the IEA presents a thorough assessment of all the influencing factors and determines that, for most reasonable scenarios, the costs for transport and storage fall into the range $12 to $15 per ton of $CO_2$ sequestered.[27] This translates into an increase in the cost of electricity from gas of between $4 and $6 per MW-hr and from coal between $8 and $10 per MW-hr over and above capture costs.

The primary risk associated with the geologic storage of $CO_2$ is ensuring that the $CO_2$ remains in the repository for thousands of years. Short-term monitoring coupled with cost-effective modeling is likely to become the accepted standard. Additional risks involve public acceptance of carbon capture and storage as a viable means to mitigate climate change along with the modification of existing laws, treaties, and regulations to accommodate geologic $CO_2$ storage, and to make the $CO_2$ emissions avoided in this manner eligible for credits in international carbon trading schemes. The cost of electricity shown in Table 13 assumes rates of return that are typical of utilities. Considering the level of maturity of the technology and other risks associated with the subsurface, commercial entities may require a higher rate of return, which may cause significant increases in the cost of electricity.

Converting a fraction of the fossil-generating fleet could have a significant impact on reducing $CO_2$ emissions with little economic impact. If such a system were applied to 15 percent of the total electric supply in the UK (added incrementally over a period of 13 years), then the annual reduction in $CO_2$ emissions would be equivalent to twice the UK's proportional share of total emission reductions required to stabilize the atmospheric $CO_2$ concentration at current levels by 2050.[28] This level of carbon capture and storage would add less than $35 per year to the electric bill of the average family over the course of the year at a total annual cost to the UK's economy of less than $2 billion.

## 6.3 Nuclear Energy

Nuclear energy represents nearly 11 percent of the non-transportation energy consumption in the U.S., and its civilian use is dedicated completely to electric power, where nuclear energy is the nation's second largest resource for generating electricity. Nuclear energy is responsible for over two-thirds of net non-emitting electricity generation (see Table 14). Output from the existing U.S. fleet of nuclear power plants has increased because utilities are now able to operate the fleet at higher capacity factors, which has recently averaged over 90 percent. In addition, a number of plants are in the process of renewing their operating licenses.

From a resource point of view, the potential energy from fission is orders of magnitude greater than combusting fossil fuels. Specifically, one metric ton of uranium for use in a

**Table 13. Incremental Impact of Carbon Capture**

| Fuel | Technology | Pre/ Post | Incremental CAPEX ($/kW) | Overall Efficiency (HHV) | Cost of Electricity Increase[3] ($/MW-hr) |
|---|---|---|---|---|---|
| Gas | Combined cycle | Pre | $6,00[6] | 38.0%[6] | $20[6] |
| Gas | Combined cycle | Post | $6,00[1] | 39.2%[1] | $20[2] |
| Coal | Pulverized coal, super critical | Post | $8,00[1] | 27.5%[1] | $40[5] |
| Coal | IGCC | Pre | $4,00[1] | 34.5%[1] | $10[4] |

Sources: [1]K. Ditzel, R. Aiken, F. Morra, and D. Wilson, *Coal-Based Integrated Coal Gasification Combined Cycle: Market Penetration Recommendations and Strategies*, September 2004. [2]David Thomas, ed., *Carbon Dioxide Capture for Storage in Deep Geologic Formations–Results from the $CO_2$ Capture Project, Vol. 1- Capture and Separation of $CO_2$ from Combustion Sources*, Elsevier 2005, Amsterdam. [3]This column shows incremental electricity price increase over fuel/technology combination without capture. [4]Booz Allen Hamilton, unpublished research, 2005. [5]Ram Narula and Harvey Wen, *Technical and Economic Comparison of $CO_2$ Reducing Technologies for Power Plants in Proceedings of 14th Conference of the Electric Power Supply Industry* CEPSI 2002, Japan, November 5-8 2002. [6]Booz Allen Hamilton, unpublished research, 2005.

27 IEA Greenhouse Gas Programme, *A $CO_2$ -Storage Supply Curve for North America and Its Implications for the Deployment of Carbon Dioxide Capture and Storage Systems in Proceedings of 7th International Conference on Greenhouse Gas Control Technologies*. Volume 1: Peer-Reviewed Papers and Plenary Presentations, Cheltenham, UK, 2005-in press.

28 Booz Allen Hamilton analysis, June 2005.

Table 14. Nuclear Power Snapshot

| | |
|---|---|
| **Total number of reactors, U.S. (worldwide)** | 104 (443) |
| **Nuclear electricity net generation** | 763,733 Million kWh |
| **Nuclear percent of electricity generation** | 20 |
| **Percent of electric capacity that is nuclear** | 10 |
| **Nuclear annual capacity factor** | 88.2 |
| **Number of states with commercial nuclear plants** | 31 |
| **U.S. uranium expenditures, 2004 ($)** | 86.9 Million |
| **U.S. uranium concentrate production (2004)** | 2.3 Million Pounds |
| **Average price for purchased uranium ($U_3O_8$) (2004)** | $12.61 per Pound $U_3O_8$ |

*Source:* EIA, 2005

light water reactor is equivalent to 10,000 to 16,000 tons of oil equivalent in an open cycle,[29] in which only four percent of the resource is consumed. In the future, many times more fuel could be consumed in a closed cycle or in fast spectrum reactor designs. The cost to build a nuclear plant, the amortized cost of electricity from nuclear power, and disposal of spent fuel is a much more dominant issue for the consumer than the commodity price of uranium.

## Fuel Resource

Uranium is an abundant, dense, naturally radioactive metal. Naturally occurring uranium consists of approximately 99.28 percent of the U-238 isotope, and 0.71 percent of the U-235 isotope. When struck by a free neutron in the thermal energy spectrum, U-235 will nearly always create a fission reaction, thus it is referred to as fissile. U-238, on the other hand, absorbs neutrons, and in doing so will yield an atom of the isotope U-239. U-239, in turn, decays to Pu-239, which is also a fissile isotope. As a result of this chain reaction, U-238 is said to be fertile. Natural uranium contains less than the amount of fissionable isotopes required to sustain a nuclear chain reaction, in most reactor designs and must be enriched. Uranium for commercial power production is enriched to 2.5 to 3.5 percent U-235. In contrast, weapons-grade uranium is highly enriched to more than 90 percent U-235.

Other fuels that often are mentioned in nuclear fuel discussions are thorium and mixed oxide (MOX). Thorium is significantly more abundant than uranium. Although thorium is not fissile itself, it is fertile: Th-232 can absorb neutrons to become the fissile isotope U-233. MOX is a mixture of uranium and plutonium that comes from the process of recycling plutonium. The MOX fuel can be used in pressurized water reactors as a direct replacement for enriched uranium fuel.[30]

29 EIA, "Thermal Energy Conversions of Nuclear Fuels," at www.eia.doe.gov, Accessed March 8, 2006.
30 Bertrand Barré, *All About Nuclear: From Atom to Zirconium*, Areva, July 2003.

## Nuclear Fuel Cycle

The nuclear fuel cycle consists of steps at the front end that lead to the preparation of uranium for use as fuel for reactor operation and back-end steps that are necessary to manage, prepare, and dispose of the radioactive spent nuclear fuel safely. The nuclear fuel cycle begins when the uranium is mined, enriched, and manufactured to nuclear fuel, which then is delivered to a nuclear power plant. After usage in the power plant, the spent fuel is stored on site for a period of time and then delivered to a final repository for geologic disposition. In some countries, spent fuel is delivered to a reprocessing plant. In reprocessing, 96 percent of spent fuel can be recycled to be returned to usage in a power plant.

***Mining, Milling, and Conversion*** – Uranium ore can be extracted through conventional mining in an open pit and underground methods similar to those used for mining other metals. Mined uranium ores normally are processed and treated chemically to extract the uranium. The milling process yields dry powder material that consists of natural uranium—"yellowcake"—that is sold on the uranium market as $U_3O_8$. The $U_3O_8$ must be converted to uranium hexafluoride ($UF_6$), which is the form that most commercial uranium enrichment facilities require.

***Enrichment*** – $UF_6$ must be enriched in the fissionable isotope if it is to be used as nuclear fuel, which is accomplished via isotope separation. The current methods for enrichment are by gaseous diffusion and gas centrifuge. The gas centrifuge method is less power-intensive and less expensive than gaseous diffusion.

***Fabrication*** – Enriched $UF_6$ is converted into uranium dioxide ($UO_2$) that then is processed into ceramic pellet form in a furnace. The pellets are stacked, according to the design specifications of each nuclear core, into tubes of corrosion-resistant metal alloy, called fuel rods. The finished fuel rods are grouped into special fuel assemblies that then are arrayed in the nuclear fuel core of a power reactor.

***Interim Storage*** – Spent fuel is stored either at the reactor site or in a common facility away from reactor sites. The spent fuel rods usually are stored in water, which provides both cooling of decay heat and shielding from radiation. A utility may opt to store fuel that has been aged in water for a number of years in modular dry storage facilities known as independent spent fuel storage installations.

***Reprocessing*** – Spent fuel discharged from light water reactors (LWR) contains appreciable quantities of fissile (U-235, Pu-239) and fertile (U-238) materials, which can be recovered from the spent fuel and recycled for use as nuclear fuel. About 96 percent of the material can potentially be recycled in this fashion, which could greatly reduce the volume of waste. However reprocessing still generates some high-level radioactive waste that must be disposed of in a deep geologic repository and such a repository needs to be built. In 1977, President Carter instituted a policy to indefinitely delay reprocessing of spent commercial-reactor nuclear fuel in the U.S., but in 1981 President Reagan lifted that ban. President Clinton did not reinstate a ban on reprocessing, but the U.S. position was not to encourage the civil use of plutonium. President Bush supports research and development on advanced reprocessing technologies while discouraging the accumulation of separated plutonium worldwide.

***Waste Disposal*** – A key issue in the nuclear power field is the safe disposal and isolation of either spent fuel from reactors or wastes from reprocessing plants. These materials must be isolated from the biosphere until the radioactivity contained in them is diminished to a safe level. Various scientific studies have concluded that deep geologic disposal is the best and safest means of isolation.

## Technologies

In the 1990s, in order to help describe and classify research and development efforts, the government created a simple classification system: Generation I (Gen-I) reactors were developed in 1950s and 1960s; Generation II (Gen-II) reactors are represented by the present fleets of the U.S. and elsewhere. Generation III (Gen-III) reactors are the advanced reactors that were developed under the U.S. Advanced Light Water Reactor (ALWR) Program in the late 1980s and 1990s and that were first deployed in 1996 in Japan. Other GEN-III reactors are under construction or ready to be ordered. Generation IV (Gen-IV) designs are a few years past the concept stage, but will not be operational before 2020.

*Light Water Reactors (LWR)* – The nuclear reactors used in the U.S. are LWRs. LWRs also account for about 85 percent of the world's nuclear electricity. Ordinary water is used as the moderator (to slow down neutrons), the cooling agent, and the working fluid. The two varieties of LWRs are the pressurized water reactor (PWR) and boiling water reactor (BWR). Water reactors are also often referred to as "thermal" reactors because neutrons are slowed down to "thermal energy" levels in order to fission U-235.

*Heavy Water Reactors (HWR)* – The Canadian CANDU reactor design is an example of a heavy water reactor. The moderator is deuterium oxide—$D_2O$ or $^2H_2O$ — and is called heavy because about half the hydrogen atoms are replaced with the heavier deuterium atoms. In this type of reactor, criticality can be achieved using natural uranium (among other things) as a fuel instead of enriched uranium. However, these types of reactors have the potential to be designed to turn uranium into weapons-grade plutonium without requiring enrichment facilities, and therefore pose a higher proliferation concern.

*Fast Breeder Reactors (FBR)* – The fast reactor uses no moderator, relying instead on fast neutrons to sustain its chain reaction. This type of reactor produces more fissile material than it consumes and can be designed to consume most of the actinides in the fuel. Thus, they can be at least 60 times more efficient with regard to uranium utilization than a normal reactor. However, abundant supplies of uranium and of enriched uranium have made this technology uncompetitive. In addition, as this type of reactor can be designed to produce weapons-grade material, it poses a greater risk of proliferation of nuclear weapons. To date, however, all known weapons programs have used the more easily built thermal reactors - LWRs with reprocessing or non-LWRs (e.g., HWRs) with on-line refueling to produce plutonium.

About 20 liquid metal–cooled fast reactors have been in operation. In addition, India is pursuing a thorium-based thermal breeder reactor due to the large reserve of thorium in that country. Japan's power program plans plutonium breeding in one experimental fast reactor. Russia's BN-600 fast breeder reactor has supplied electricity to the grid since 1981 and has the best operating and production record of all of Russia's nuclear power units.

## Installed Base of Technologies

The U.S. has 104 commercial nuclear power plants today, with 103 in operation and one unit in restart. (See Figure 22). About two thirds of these (69) are PWRs, which generate 65,100 MW. The remaining 35 units are BWRs, producing 32,300 MW. About half of these U.S. commercial power plants (53) came on line from 1969 to 1979, with most of the rest (45) in the 1980s. Only five plants have come on line since 1990, with the last in 1996. The last application for a new reactor (that was actually built) was submitted in 1973. Despite the lack of new construction, commercial nuclear capacity has increased in recent years as a result of license extensions and up-rating (upgrading) of existing reactors.

The two primary vendors of nuclear reactors in the U.S. are General Electric and Westinghouse, for which the installed base represents the majority of BWRs and PWRs, respectively. Other U.S. reactors were manufactured by Combustion Engineering (now part of Westinghouse) and Babcock and Wilcox (now part of AREVA), Framatome ANP, a subsidiary of the French company AREVA, is a major nuclear manufacturer, as is Japan's Mitsubishi. AREVA is adapting its latest reactor design for the U.S., known as the USEPR.

## Technological Developments and Licensing Progress

The commercial nuclear industry, with some cost-shared assistance from DOE, has developed a number of types of advanced reactors, most of which build upon the LWR experience in the U.S., Europe and Japan.[31] One is an advanced boiling water reactor (ABWR), three of which are operational in Japan.

The nuclear industry selected one standardized design for both a large ABWR and a medium-sized AP-600 (AP for "Advanced Passive") for detailed, first-of-a-kind engineering. The NRC has given final design certification to the AP-600 and has recently granted the same to the AP-1000. The reactor size is projected at 1,100 MWe, with construction time estimated at 36 months and operating life of 60 years. It is also capable of running on a full MOX core.

Also under development is the Economic and Simplified BWR (ESBWR), a 1,390 reactor by General Electric, based on its ABWR design, and a 1,500 MWe version is awaiting NRC design certification, and the AREVA USEPR – a U.S. version of a 1600 MWe PWR currently under construction in Finland.

The Gas Turbine–Modular Helium Reactor (GT-MHR) is a larger design with 285 MWe modules with thermal efficiency of 48 percent. Overnight capital costs are projected to be under $1,000/kW and power costs at $0.029/kWh.

NRC design approvals are valid for 15 years. Safety issues within the scope of the certified designs underwent an extensive public process and should not be open to legal challenge during licensing for particular plants. Utilities can obtain a single "combined" license (COL) from the NRC before construction begins to both construct and operate a reactor before construction begins. Table 15 provides the certification status of new reactors in the U.S.

*Asia* – In Japan, the first four ABWRs are operational, with construction costs about $2,000/kW and power costs at about $0.07/kWh. In addition, several 1,350 MWe units are under construction in Japan and Taiwan. Hitachi has completed systems design for three sizes of this reactor design—600, 900, and 1,700 MWe—all with standardized features and shorter construction times. A 1,500 MWe advanced PWR is under development by Westinghouse and Mitsubishi and four utilities. It will combine active and passive cooling systems and have a higher than 55 GWd/t fuel burn-up.[32] Mitsubishi is also participating in the development of Westinghouse's AP-1000 reactor. In South Korea, the Korean Next-Generation Reactor (APR-1400) is an advanced PWR design. This reactor is sized at 1,400 MWe, with an expected initial capital cost of $1,400 per kilowatt, dropping to $1,200/kW for later units, and a construction time of 48 months. The Russian designed Gidropress 1,000 MWe V-392 units are being built in India. In addition, two Russian designed 1,000 MWe VVER-91 units are being built in China.

*Europe* – Framatome's 1,600 MWe European PWR will have the highest thermal efficiency of any LWR (36 percent). Construction of the first EPR in Finland is underway. Construction of the second EPR will begin next year in France. Framatome also is developing a 1,000-1,290 MWe BWR (SWR 1000). Westinghouse is developing a 1,500 MWe BWR 90+ unit in Sweden. In Russia, the VVER-1500 V-448 design is expected to be completed in 2007.

*Canada* – Based on its CANDU-6 reactors, Atomic Energy of Canada, Ltd. (AECL) is developing the 925-1,300 MWe CANDU-9 reactor. This reactor is designed to burn a range of fuels including natural uranium; slightly-enriched uranium; MOX; spent PWR fuel, both from reprocessing and direct use; and thorium. Also based on its CANDU-6 reactors, AECL is developing a smaller, 750 MWe (ACR-700) reactor, with a high burn-up, extending the fuel life by about three times and reducing the volume of high-level waste accordingly. Capital costs are estimated at $1,000/kWe, with operating costs of $0.03/kWh. Construction time could be as low as three years. In Ontario, AECL is developing the 1,100 MWe to 1,200 MWe, ACR-1000, with initial operations expected in 2014.

*South Africa* – The Pebble Bed Modular Reactor (PBMR) is a high temperature gas–cooled reactor. These reactors will be small (165 MWe), with a thermal efficiency of about 42 percent. Construction cost is estimated at $1,000/kW and power costs below $0.03/kWh, and a demonstration plant for commercial operation is projected to be operational in 2006.

31 The technological developments sections heavily referenced the Uranium Information Centre, /www.uic.com.au/, and Nuclear Regulatory Commission, /www.nrc.gov/.

32 Fuel Burn-up (GWd/t U) - Thermal energy produced in the nuclear plant from one metric ton of enriched uranium. GWd stands for Gigawatt-days, 1 GWd = 24 million kilowatt-hours. For PWR's, the range is between 40 and 43.4 GWd/t U, and for BWR's, between 33 and 40 GWd/t.

**Table 15. Certification Status for New Reactors in the United States**

| Reactor Design | Lead Vendor(s) | Type | Status at NRC (2005) |
|---|---|---|---|
| System 80+ | Westinghouse BNFL | PWR | Certified |
| ABWR | GE, Toshiba, Hitachi | BWR | Certified |
| AP600 | Westinghouse BNFL | PWR | Certified |
| AP1000 | Westinghouse BNFL | PWR | Certified |
| ESBWR | GE | BWR | Review underway |
| SWR-1000 | Framatome ANP | BWR | Pre-certification, deferred |
| ACR700 | AECL | Hybrid | Pre-certification, deferred |
| PBMR | Eskom | HTGR | Pre-certification, deferred |
| GT-MHR | General Atomic | HTGR | Pre-certification |
| IRIS | Westinghouse BNFL | PWR | Pre-certification |
| EPR | Framatome ANP | PWR | Pre-certification |

*Source:* EIA, at www.eia.doe.gov/cneaf/nuclear/ page/analysis/nucenviss2.html

**Figure 22: Location of Commercial Nuclear Reactors**


*Source:* Nuclear Energy Institute, 2005

## Gen-IV

DOE, as part of an international group, is planning the next generation nuclear plant. The Gen-IV Technology Roadmap was issued in 2003, and six concepts were selected for further development and deployment in the timeframe of 2010 to 2030. These systems are focused on improvements in sustainability, economics, safety, reliability, proliferation resistance, and resistance to attacks. Four systems are designated for the possible production of hydrogen. Most employ a closed fuel cycle minimizing high-level wastes.

## Prices and Costs

In 2004, all categories of activity in the U.S. uranium market increased for the first time since 1998. Two-and-a-half-million pounds of uranium were mined in the U.S.—an increase of 11 percent over the previous year—and uranium concentrate production rose to 2.3 million pounds of $U_3O_8$, an increase of 14 percent. Owners and operators of civilian nuclear power reactors in the U.S. purchased a total of 64 million pounds of $U_3O_8$ (equivalent) during 2004. Approximately 19 percent of all uranium purchased was U.S.-origin at an average price of $11.87/lb., while foreign-origin uranium had an average price of $12.76/lb. In 2004, 15 percent of the purchased uranium involved spot contracts at an average price of $14.77/lb., while the remaining 85 percent involved long-term contracts at $12.24/lb.

Table 16 summarizes approximate cost factors discussed in detail in the section on technology above for the various nuclear technologies. These cost estimates, as claimed by developers, are assumed to be for the "nth" unit (i.e., assumed to have taken advantage of the learning curve). Capital cost estimates range from $1,000/kW to $2,000/kW, with an average of around $1,300/kW. Operating costs range from $0.029/kWh to $0.07/kWh, with most hovering around $0.03/kWh.

A study by MIT in 2003[33] provides comparative cost estimates for nuclear, coal, and natural gas (see Table 17). That estimate agrees with the high end for capital costs and is the range for variable operating costs at $0.047/kWh included in that table.

Several large utilities—Exelon, Dominion, and Entergy—have applied to the NRC for early site permits for reactors with the goal of testing, using the NRC's streamlined licensing process, to preserve the option of building a nuclear plant. More recently a number of utilities have expressed interest in preparing a COL application for construction of new plants (see Table 18).

In assessing the cost competitiveness of nuclear energy, decommissioning and waste disposal costs must be taken into account. Both costs are much more substantial for nuclear power than they are for other energy options. The nuclear industry pays into a fund designed to address the waste disposal issues. That fund is to be used to develop and operate the National Nuclear Waste Management System, including the design, licensing, and construction of the U.S. nuclear waste repository and associated transportation and program management expenses. Also, individual owners pay into a decommissioning trust fund to cover these costs when needed.

Investors consider large upfront capital investments to be risky, especially because of the uncertainties in construction costs and delays, licensing, and public pressure, which was the reason why incentives were provided in the Energy Policy Act of 2005.

## Benefits and Challenges

Nuclear energy is a good source of baseload electricity generation because of its low operating costs and high capacity factors, thus providing the American consumer with reliable and high quality electricity.

Consumers benefit environmentally from nuclear energy in that it emits no air pollutants or greenhouse gases. Thus, it does not contribute to either current clean air challenges or to issues associated with climate change. Due to the abundance of uranium, the constrained resource is the number of power plants rather than the fuel itself; therefore the consumer is not significantly impacted by issues of supply availability and dependence on foreign sources of supply.

**Table 16. Summary of Cost Factors for Nuclear Technologies**

| Country | Developer | Reactor | Size | Constr. Time | Capital Cost (Est.) | | Life-cycle | Burn Up |
|---|---|---|---|---|---|---|---|---|
| | | | (MWe) | (mo) | ($/kW) | (¢ /kWh) | (yr) | (GWd/t) |
| U.S. | Westinghouse | AP-1000 | 1100 | N/A | 1,200 | 3.5 | 60 | N/A |
| U.S.-Japan | GE-Hitachi-Toshiba | ABWR | 1300 | 34 | 2,000 | 7.0 | 60 | N/A |
| USA-Int'l | Westinghouse | IRIS | 335 | N/A | 1,000-2,000 | N/A | N/A | 60 |
| U.S.-Russia (et al) | Gen Atomics-Minatom | GT-MHR | 285 | N/A | 1,000 | 2.9 | N/A | 50 |
| South Korea | Westinghouse (derived) | APR-1400 | 1400 | 48 | 1,400 | N/A | N/A | N/A |
| France | AREVA | EPR | 1600 | N/A | N/A | N/A | 60 | 65 |
| Canada | AECL | CANDU-9 | 925-1300 | N/A | N/A | N/A | N/A | N/A |
| Canada | AECL | ACR | 750 | N/A | 1,000 | 3.0 | N/A | N/A |
| South Africa | Eskom-BNFL | PBMR | 165 | N/A | 1,000 | 3.0 | N/A | 90 |

*Source:* Uranium Information Centre, *Australia, Advanced Nuclear Power Reactors Briefing*, May 2005

33 *The Future of Nuclear Power. An Interdisciplinary MIT Study*, MIT, 2003.

Challenges associated with nuclear energy revolve around consumer concerns on safety, proliferation and terrorism, and waste disposal.

*Safety* – The American consumer's primary safety concern regarding nuclear energy is the possibility of an uncontrolled release of radioactive material, leading to radiation exposure off-site. There have been two major accidents in the history of civilian nuclear power generation. The first was at the Three Mile Island nuclear power plant, near Middletown, PA, on March 28, 1979. The accident occurred when a mechanical malfunction and series of operator errors resulted in a significant amount of cooling water draining from the reactor, which then caused "a partial meltdown of the TMI-2 reactor core."[34] The accident resulted in the release of small amounts of radioactive materials, but the radiation was largely contained within the containment area. All credible studies show that no adverse health or environmental consequences occurred due to the accident, and researchers continue to monitor the area.[35] The second accident was at

**Table 17. Comparison of Cost Components for Nuclear, Coal and Gas**

| Size | Units<br>MWe | Nuclear<br>1,000 | Coal<br>1,000 | NGCC<br>1,000 |
|---|---|---|---|---|
| Construction period | Yr | 5 | 4 | 2 |
| Overnight cost | $/kWe | 2,000 | 1,300 | 500 |
| Fixed O&M | $/kWe/yr | 63 | 23 | 16 |
| Capacity factor | Percent | 85% | 85% | 85% |
| Variable O&M | Mills/kWh | 0.47 | 3.38 | 0.52 |
| Heat rate | | 10,400 | 9,300 | 7,200 |
| Fuel costs | $/MMBTU | 0.47 | 1.2 | 3.5 |
| Decommissioning cost | $MM | 350 | — | — |
| Incremental capital costs | $/kWe/yr | 20 | 15 | 6 |
| Operating life | Yr | 60 | 40 | 40 |

***Source*: MIT, *The Future of Nuclear Energy,* 2003**

**Table 18. Status of New Nuclear Plant Development**

| Company | Site | Early Site Permit | Design# of Units | Construction/ Operating License |
|---|---|---|---|---|
| Dominion | North Anna, VA | Under review, approval expected 2007 | ESBWR (1) | COL application in 2007 |
| NuStart (TVA) | Bellefonte, AL | Expected to go straight to COL | AP1000 ( 2) | COL application in 2007 |
| NuStart (Entergy) | Grand Gulf, MS | Under review, approval expected early 2007 | ESBWR (1) | COL application 2007/2008 |
| Entergy | River Bend, LA | Will go straight to COL | ESBWR (1) | COL application in 2008 |
| Southern Company | Vogtle, GA | Under development, to be submitted mid-2006 | AP1000 (2) | COL application in 2008 |
| Progress Energy | Harris, NC Florida to be determined | Will go straight to COL | AP1000 (4) | COL applications in 2007/8 |
| South Carolina Electric & Gas | VC Summer, SC | Will go straight to COL | AP 1000 (2) | COL application in 2007 |
| Duke | Cherokee, SC | Will go straight to COL | AP1000 (2) | COL application in 2007/8 |
| Exelon | Clinton, IL | Under review, approval expected 2007 | Not yet determined | |
| UniStar | Calvert Cliffs, MD or Nine Mile Point, NY | Will go to COL but submit siting information early | EPR (1) | 2008 (COL and EPR design certification will be phased, yet parallel activities) |

*Source:* Nuclear Energy Institute, *The Outlook for New Nuclear Power Plant Construction*, February 2006

34 U.S. Nuclear Regulatory Commission, "Fact Sheet on the Accident at Three Mile Island," at www.nrc.gov/.

35 Some studies claim that no radiological harm was inflicted due to the accident, and other studies claim the opposite. See Steven Wing, "A reevaluation of cancer incidence near the Three Mile Island nuclear plant: the collision of evidence and assumptions," *Environmental Health Perspectives:* 105, January 1997.

the Chernobyl nuclear power plant (Ukraine, 1986), in which the destruction of the reactor by explosion and fire killed 31 people and had significant health and environmental consequences. The Chernobyl accident resulted in radiation exposure dangerous enough to permanently evacuate 135,000 people from within a 20-mile radius of the plant. Even before the accident, Chernobyl-type plant designs had been criticized as too unsafe.

The NRC-mandated safety indicator is the calculated frequency of degraded core or core melt accidents. The NRC specifies that reactor designs must meet a one-in-10,000-year core damage frequency, but modern designs exceed this requirement. Regulations require that any core-melt accident must be confined to the plant itself, without the need to evacuate nearby residents. To achieve optimum safety, nuclear plants in the West operate using a defense-in-depth approach, one that uses redundant and diverse systems to detect problems, control damage to the fuel, prevent significant radioactive releases, and confine the effects of severe fuel damage to the plant itself. The safety systems include a series of physical barriers between the radioactive reactor core and the environment, the provision of multiple safety systems, each with backup and designed to accommodate human error. The fuel is in the form of ceramic pellets, and radioactive products remain bound inside these pellets as the fuel is burned. The pellets are packed inside zirconium alloy tubes to form fuel rods, which are confined inside a large steel pressure vessel with walls about 20 centimeter thick, enclosed inside a steel and/or concrete containment structure with walls at least one meter thick. Safety systems account for about one quarter of the capital cost of such reactors.[36]

Some advanced Gen-III reactors are designed to be inherently safer based on passive safety features. Passive safety depends on physical phenomena such as convection, gravity, or resistance to high temperatures instead of operator intervention or the functioning of engineered electrical or mechanical components. Many designs also incorporate negative void coefficient, which means that beyond an optimal level, as the temperature increases the efficiency of the reaction decreases and the reaction slows down automatically.

Onsite personnel safety includes controlling doses of radiation by the use of remote handling equipment, physical shielding, and limits on the amount of time workers can spend in certain areas, and continuous monitoring of individual doses and of the work environment.

***Proliferation and Terrorism*** – Public safety and system security are significant consumer concerns, thus proliferation and the potential for nuclear terrorism are areas of consumer interest. Non-proliferation concerns in the civilian nuclear power sector involve potential for diversion of nuclear materials, leakage of sensitive technologies, undeclared fuel cycle facilities, and the withdrawal from the Non-Proliferation Treaty.

With the terrorist events in the U.S. of September 11, 2001, the focus of non-proliferation efforts has expanded from the spread of nuclear weapons to the nuclear threats posed by terrorists. A conference of experts in non-proliferation and nuclear power addressed these concerns and concluded that the civilian nuclear fuel cycle is not the greatest risk to proliferation; instead, inadequately secured nuclear material, weapons, and highly enriched uranium at research reactors pose a more significant risk.[37]

Various studies since September 11, 2001 have analyzed similar attacks on nuclear sites and demonstrate that nuclear reactors would be more resistant to such attacks than virtually any other civil installations. An analysis conducted by the Electric Power Research Institute in 2002 analyzed the impact of a fully fueled Boeing 767-400 flying into a reactor and concluded that no part of the aircraft or its fuel would penetrate the containment. Analysis of spent fuel storage pools shows no breach, and dry storage and transport casks retain their integrity.

***Waste Disposal*** – Consumer interests in safe and secure disposal of nuclear waste is both a concern over environmental protection and of public safety. Under the Nuclear Waste Policy Act of 1982, as amended, DOE has responsibility for the development of the waste disposal system for spent nuclear fuel and high-level radioactive waste. Currently, nuclear waste is temporarily stored above ground at some 130 locations in 39 States, including every nuclear reactor site in the U.S. Water cools the spent fuel and absorbs the radiation. Since 1986, more than a dozen U.S. nuclear power plants have supplemented their storage capacity by building above ground, dry storage facilities at their plant site. Of all long-term waste disposal options, such as leaving the waste where it is, in sub-ocean floor or deep hole disposal, or sending it into outer space, scientists determined that the most practical solution was storage in stable, deep, geologic structures.[38]

Congress amended the Nuclear Waste Policy Act in 1987 and directed DOE to focus all research efforts toward development of Yucca Mountain, a remote location in Nevada designated by the Act as the most appropriate repository site for spent nuclear wastes. After years of study, President Bush signed House Joint Resolution 87 on July 22, 2002, which gave DOE the authority to take the appropriate

36 Office of Civilian Radioactive Waste Management, 2005.

37 Strengthening the Nuclear Nonproliferation Regime: Focus on Civilian Nuclear Fuel Cycle, 14th International Security Conference, Sandia National Laboratory, 2005.

38 DOE Office of Civilian of Radioactive Waste Management, "Yucca Mountain Fact Sheet," at http://www.ocrwm.doe.gov/ymp/index.shtml, Accessed on March 7, 2006.

next steps in establishing Yucca Mountain as a nuclear spent fuel repository.[39] DOE is working toward a license submittal to the NRC for the construction and operation of the Yucca Mountain repository. Several roadblocks may add delays in that project. The most significant unresolved issue is that standards to govern the performance of the repository are still uncertain as a result of a 2004 decision by the DC Circuit overturning EPA's radiation protection standard. Additionally, public concern from activists and political groups in Nevada and neighboring States has focused on the transport of the spent fuel from current onsite storage to the repository. As of 2003, the U.S. had accumulated about 49,000 metric tons of spent nuclear fuel. Under current law, a total of 70,000 metric tons of spent nuclear fuel and solid high-level radioactive waste could be placed in Yucca Mountain.

## 6.4 Renewable Energy Resources

This discussion of renewable fuels covers hydroelectric, biomass, wind power, solar power, and geothermal energy sources. Renewable energy contributes approximately six percent of total energy in the U.S. Approximately 97 percent of this contribution is in the stationary sector. Biomass and hydroelectric power represent the lion's share of renewable energy consumption, with 47 and 45 percent, respectively, of the total. For the generation of electric power, renewable fuels constitute approximately 12 percent of all electricity capacity, with 10 percent produced by hydroelectric power and approximately one percent each for wind power and biomass.

### *Hydroelectric Power*

Hydroelectric power accounts for about 96,000 MW of power produced from 4,100 generators.[40] Hydroelectric power can be grouped into three broad classes: impoundment, diversion, and pumped storage. Impoundment facilities utilize a dam to store river water in a reservoir. Typically, these are larger hydropower systems. Diversion—or "run-of-river"—facilities channel a portion or all of the river flow through a canal or penstock, which usually requires some kind of dam or diversion structure. A pumped storage facility stores energy by pumping water from a low reservoir to a higher reservoir whenever energy prices are low (off-peak). Whenever electricity demand and prices are sufficiently high, water is allowed to flow down to the lower reservoir through a turbine to generate electricity. Impoundment and run of the river facilities constitute about 80 percent of the capacity, with pumped storage facilities representing about 20 percent.[41]

39 *Ibid.*
40 EIA, "Existing Capacity by Energy Source," 2003.
41 *Ibid.*

DOE classifies hydropower facilities into three size categories: (1) *micro*, those with less than 100 kW; (2) *small*, between 100 kW and 30 MW; and (3) *large*, those greater than 30 MW. Micro facilities have a negligible impact in terms of installed capacity and number of facilities, with less than 35 units representing three MW of capacity. Small hydroelectric has about 3,200 generating units representing 18,000 MW of installed capacity and large hydroelectric has about 900 generating units with 78,000 MW of installed capacity.[42] Two other important terms are *incremental hydropower*, which is further developing existing infrastructure through efficiency improvements and capacity additions, and *kinetic hydropower*, which refers to any technology that uses water to generate electricity but does not require the use of a dam or impoundment.

## Fuel Resource and Technology

There are three basic hydroelectric technologies, the Pelton turbine, Francis turbine, and axial flow propeller turbines, and the type of technology selection is primarily driven by height of the standing water or "head" available. Pelton turbines have one or more high pressure jets impinging on a water wheel (or runner) essentially containing many curved buckets. Their use is limited to high head applications greater than 50 feet and ranging up to 6,000 feet and can be as large as 200 MW.[43] A Francis turbine has a runner with fixed vanes with the water entering in a radial direction and discharged axially. It can operate in heads of 10 feet to 2,000 feet and can be as large as 800 MW. In the axial flow propeller technology, the runner is like a boat propeller, and is either fixed-blade or adjustable-blade (Kaplan), and water flows axially to drive the blades. Propeller turbines can operate from 10 to 300 feet and can be as large as 1,000 MW but tend to be smaller. Kaplan turbines have both adjustable runner blades and wicket gates (flow control gates) to optimize efficiency in all river flow conditions. Kaplan turbines can be used in low head applications of 10 to 300 feet and can be up to 400 MW.

New hydroelectric power generation potential could be significant. Of the approximately 75,000 dams in the U.S., only about three percent produce electricity. The Idaho National Laboratory estimates there is up to 21,000 MW of unused capacity at existing facilities, some of which could be developed into hydropower without the need for additional dams.[44] Up to 4,300 MW of new hydropower generation could be achieved by incremental hydropower. Depending on resources, incremental hydropower can be extremely cost-effective, often at a cost of about 2¢ per kWh. The potential for micro, low-head, kinetic, and low-power hydropower

42 *Ibid.*
43 DOE Energy Efficiency and Renewable Energy (EERE) HydroPower, www.eere.doe.gov/RE/hydropower.htm.
44 *Ibid.*

development is also promising and sidesteps some of the traditional complaints for hydropower.

However, both greenfield and existing dams may be difficult to develop and construct because of a number of factors, including public sentiment; environmental impact issues, including impacts on fish and ecosystems; high capital cost; lack of long-term financing and power purchase agreements; and long lead times for licensing and construction. Considering that some existing hydro capacity may be decommissioned and the difficulty of developing new capacity, hydroelectric power still faces obstacles to accelerated growth. Despite its potential, without a significant program to encourage development, hydropower will likely make additions to its total installed capacity at historical rates and will only play a moderate role in meeting nationwide demand projections, though its regional impact could be more substantial.

## Environmental Issues

Hydroelectric technology has many environmental benefits, but it also can have negative environmental impacts, both during the construction phase and during operations. One of the most significant is its impact on fish populations and is manifested in several ways, including: fish injury or mortality while passing through the turbines; impedance of fish migration; loss of fish habitat; and detrimental effect of water quality and quantity.

To address these negative impacts, FERC imposes fish mitigation obligations as part of the licensing requirements for hydroelectric facilities. These include installation of fish ladders, fish screens, and fish deterring systems; establishment and maintenance of new fish habitat; curtailing of water flows during dry seasons; and monitoring water quality (dissolved oxygen). These measures are site-specific and can be quite costly. Yet, new technologies are being developed to reduce the impact to fish populations. A new advanced design turbine at the Wanapum Dam in Washington includes comprehensive design improvements for improved fish survival, operational performance, and reduced maintenance costs. In addition to showing nearly 98 percent survival rate for juvenile salmon, the six blade turbines have shown a 14 percent increase in power generation and a three percent increase in water efficiency, which can be critical during droughts.[45]

## Prices and Costs

Because hydroelectric power has no fuel cost and many facilities cannot store the upstream water, hydroelectric power is typically bid at or below its variable operating and maintenance costs to ensure that it gets dispatched in all periods during the day. Typically that bid price is in the $0.5 to $1.5/MWh range but can vary widely depending on market conditions and operating strategy. Investment costs for a typical hydroelectric facility are $1,700/kw to $2,300/kw installed with a useful life of 50-plus years.[46] Operating and maintenance costs are around $4.5/MWh yielding total costs of $24/MWh. Hydroelectric facilities typically have very high availabilities, but capacity factors of 40 to 50 percent are typical due to the availability of water. For new plants to be economically feasible, long-term financing must be available in the marketplace. Currently, the financial community is uncomfortable with providing long-term financing on a merchant basis and would prefer to see long-term power purchase agreements. Because of the high capital costs, long contract periods are required in order to recover investment costs.

## Benefits and Challenges

Hydroelectric power, a low-cost, non-intermittent renewable resource, reduces the nation's reliance on imported fuels. As a clean source of generation with no emissions, hydroelectric power generation supports the consumer interest in a non-polluting fuel source. It has many environmental benefits including the provision of (1) recreational areas; (2) irrigation and farm/livestock water; (3) flood control; (4) public water supply; and (5) displacement of dirtier fossil fuel generation technologies. Although many States have renewable energy mandates, many of them do not consider hydroelectric power a renewable energy source (or limit its inclusion as renewable to small or micro facilities) because the large existing base of hydroelectric power has the potential to create distortions in the State's renewable energy initiatives and hinder the development of other renewable sources.

## Regulatory Drivers

FERC has jurisdiction over hydroelectric facilities. FERC issues licenses for a period of 30 to 50 years. The licensing process is extensive and may take several years. It includes consulting with stakeholders, identifying environmental issues through scoping, and preparing such environmental documents as Environmental Assessments or Environmental Impact Statements. Once the license expires, FERC can issue a new license (re-license), the Federal government may take over the project, or the project may be decommissioned.

Several of the largest hydroelectric projects are managed by the Federal Bureau of Reclamation, the Corps of Engineers, and the Power Marketing Administrations (PMAs). The first

45 Grant County Public Utility District, "Advanced Turbine Project," available at www.gcpud.org, accessed March 14, 2006.

46 DOE Idaho National Laboratory (INL) at http://hydropower.inel.gov/hydrofacts/plant_costs.shtml, accessed March 14, 2006.

two of these agencies build and maintain the dams, while the PMAs are responsible for managing and marketing the power from these water projects. All of these PMAs act as wholesale power marketers. In addition, the Tennessee Valley Authority (TVA) and the Bonneville Power Administration (BPA) both have missions that extend beyond marketing to encompass a responsibility to serve the load in their respective regions.[47] Each of these agencies has authorizing legislation that dictates the ways in which they are to carry out their respective functions. In addition, as Federal entities, they fall within the purview of the National Environmental Policy Act (NEPA), the Endangered Species Act, and other pieces of legislation designed to protect fish and wildlife. Over the next five years, about 150 FERC hydroelectric licenses will expire, representing more than 12,000 MW of installed hydro capacity,[48] or will be reviewed for re-licensing by FERC, some of which will likely be decommissioned.

### *Biomass*

Biomass includes all plant and animal-derived material that can be used for fuel. Domestic biomass feedstocks are primarily forestry and agricultural residues, as well as dedicated energy crops, and include corn and fast-growing grasses and trees, specifically switchgrass, hybrid poplar, and willow. Animal wastes that can be converted into usable feedstocks are also classified as biomass. Municipal solid waste (MSW), which is trash collected and typically disposed of in landfills, is sometimes incinerated to generate electricity or district heating. MSW is not biomass, but is sometimes classified as such simply because it does not fit neatly into any other fuels designations.

Biomass can also be converted to ethanol. Starches and sugars, such as those found in corn kernels—which have been the primary domestic feedstock for ethanol—make up a small proportion of available biomass materials. The lignocellulosic, or "woody" parts of a plant, form the bulk of most plant materials. These include materials typically regarded as wastes that require disposal, such as corn stover (husks and stalks), straw, or wood.

## Fuel Resource and Technology

In terms of total energy (not just electricity, but heat, steam, and other energy uses) biomass has surpassed hydroelectric power as the largest overall domestic source of renewable energy.[49] Biomass supplies more than three percent of the total consumption of energy, primarily through the production of industrial heat and steam by the pulp and paper industry and electrical generation with forest industry wastes and MSW. In 2002, 9,700 MW of generation capacity electricity came from biomass, including 5,800 MW from forest and agricultural residues and 1,900 MW from MSW.[50] EPA reported 95,000 tons of MSW burned per day at 97 sites in 2001.

DOE's Biomass Program estimates that 512 million dry tons of biomass, equivalent to 8.09 quadrillion BTUs (or quads) of primary energy, could be available initially at less than $50/dry ton delivered. Of this amount, 36.8 million dry tons (0.63 quads) of urban wood wastes were available in 1999. In the wood, paper, and forestry industrial sectors, the estimate is that 90.5 million dry tons (1.5 quads) of primary mill residues were available in 1999 and 45 million dry tons (0.76 quads) of forest residues were available at a delivered price of less than $50/dry ton. An estimated 150.7 million dry tons (2.3 quads) of agricultural residues (corn stover and wheat straw) could be available annually.

To estimate the upper limit on converting MSW to energy, multiply the total amount of MSW generated annually (subtracting recycling) by 600 kWe per ton of material. According to EPA, total MSW generated in 2003 was 236.2 million tons (4.5 pounds per person per day), with a recycling rate of 30.6 percent, which yields about 11,200 MWe.[51]

## Technologies

Biomass is converted to heat and power via direct combustion, or can be converted into gas prior to combustion. Agricultural or wood wastes are either burned in a conventional steam boiler or co-fired in smaller quantities with fossil fuels (typically coal). Biomass gasification, which is analogous to coal gasification, is a thermo-chemical process that converts the solid biomass into a gaseous fuel, largely composed of CO, $CO_2$, methane, and hydrogen. MSW in landfills naturally decomposes into a gaseous mixture of methane (~60 percent) and $CO_2$ (~40 percent), which is harvested actively. Anaerobic digestion is a more specifically engineered version of the same process that utilizes bacteria and yields high levels of methane.

Typical biomass power boilers are in the range of 20 MW to 50 MW, compared with coal-fired facilities that are in the range of 100 MW to 1,500 MW. The small-capacity plants tend to be lower in efficiency because the improved efficiency equipment is not economical in the smaller plants. Whereas overall efficiency could surpass 40 percent, actual plants have efficiencies in the low 20 percent range. Therefore,

47 The remaining PMAs include the Western Area Power Administration (WAPA), the Southeastern Power Administration, and the Southwestern Area Power Administration.
48 Douglas G. Hall, DOE–EERE, Hydropower Capacity Increase Opportunities, May 5, 2005.
49 Total biomass energy in 2004 reached 2.845 quads, passing hydropower at 2.725 quads. See EIA renewable energy data tables online at http://www.eia.doe.gov/fuelrenewable.html, accessed March 7, 2006.
50 EIA, Renewable Energy Annual 2002, released August 2004.
51 EPA, Municipal Solid Waste Data Facts, viewed at http://www.epa.gov/msw/facts.htm.

co-firing with coal is more economical. Many existing coal plants can co-fire biomass without significant modification; with proper tuning and biomass inputs up to 10 percent of the fuel, they can achieve similar efficiencies to coal by itself (33 to 37 percent).[52] The forest products industry consumes 85 percent of all wood waste used for energy in the U.S.[53] They generate more than half of their energy from such recycled products as wood and black liquor, a byproduct of wood pulping, at higher efficiencies and lower costs than conventional technologies.

DOE's Biomass Program points the way toward the more economical utilization of biomass going forward. The sugar platform and the thermo-chemical platform are the two basic types of technologies that would generate a base of chemicals from which industry could make a wide range of fuels, chemicals, materials, power, and/or heat. The technology of the sugar platform uses enzymatic hydrolysis of cellulose and the subsequent fermentation of the sugars into the chemicals that become the building blocks for fuels or other materials. Separated lignin also can be processed into valuable products or burned efficiently. Thermo-chemical platform technology heats biomass with limited oxygen to gasify it to synthesis gas or liquefy it to pyrolysis oil.

## Prices and Costs

***Wood-fired Plants*** – Standard wood chip–fired power plants cost approximately $1,800 per kWe. The operating costs are approximately $20 per MWh. Fuel costs range from $2.00 to $2.50/MMBTU delivered to the facility. With heat rates in the range of 13,000 BTU/kWe, the fuel costs are $26 to $32 per MWh.

***Municipal Solid Waste (MSW)*** – The current day cost of a mass-burn waste-to-energy plant is approximately $175,000 per ton of daily capacity for a system in the range of 1,200 tons per day.[54] The power output for this type plant is approximately 27.5 MWe, at approximately $7,640/kWe. Although this cost is high compared with other technologies, waste disposal (that is, the avoidance of landfill costs) is the primary purpose, with power as the byproduct. The operating cost of such a system is approximately $45 to $55 per ton of waste processed, including ash disposal, or $82 to $100/MWh.

***Animal Waste/Manure*** – A typical source of waste manure is poultry litter. The current day cost of this type of system is approximately $2,600/kWe. The non-fuel operating costs are approximately $30/MWh, including fixed and variable costs. The cost of the poultry litter varies such that the fuel costs could range from $0 to $5 per ton of litter and fuel transportation in the range of $10 to $15 per ton. At $15/ton of litter, the cost of fuel is approximately $1.80/MMBTU, or $26/MWh (at a 14,500 BTU/kWe heat rate).

## Benefits and Challenges

The U.S. has large amounts of land that can be devoted to this domestic, renewable energy resource. The aforementioned conservation lands, among others, can be utilized for energy crops and provide an opportunity for farmers to create value using their land, as well as save taxpayer dollars. The dedicated energy crops discussed earlier were selected based on their advantageous characteristics: high energy content, low fertilizer requirements, excellent retention of nutrients in the soil, superior capabilities to prevent the erosion of soil, and they can be grown on land not economically suitable for food crops. Depending on the energy crop, the harvesting cycle ranges from annually (switchgrass, corn) to more than five years (poplar).[55]

Biomass also contributes to the consumer's interest in environmental protection. Direct emissions of pollutants from burning biomass is negligible and, because the carbon the plant emits during combustion is the same carbon it absorbs during its lifecycle, most forms of biomass are essentially carbon neutral. Part of the emissions from burning coal comes from its combustion in nitrogen-rich air at high temperatures. Co-firing coal with biomass reduces the overall temperature, resulting in NOx reductions of more than 50 percent. Co-firing further offsets the fuel-borne emissions of NOx and $SO_2$. The burning of biodiesel, ethanol, or blends of these with their respective fossil fuels in combustion engines can reduce the associated emissions dramatically. Furthermore, biomass is biodegradable, so the hazards from spills are reduced. Finally, landfill gas and manure create methane, a powerful greenhouse gas, that otherwise is either released or flared, so the capture of this methane as a fuel provides a benefit to the environment.

In addition, many biomass feedstocks include materials typically regarded as wastes that otherwise would require disposal. Corn stover is relatively unused and available and requires very little additional resources to produce it. A similar concept translates into subtracting the avoided landfill costs whenever calculating the cost of gasifying or combusting MSW.

Biomass does not provide an affordable source of power to consumers. The energy density of biomass feedstocks is low. In general, biomass has about 16 MJ/kg and about 500 kg/m,3 compared with coal at 25 MJ/kg and 1300 kg/m3. Biomass

52 ROAM Consulting and Ultra Systems Technology, "Co-Firing of Biomass with Coal," August 15, 2000.

53 DOE's Biomass Program, 2005.

54 Herbert M. Kosstrin, "Renewable Technology Report," R.W. Beck, 2003.

55 DOE's Biomass Program, 2005, viewed at http://www.energy.gov/energysources/bioenergy.htm.

feedstocks therefore tend to have very high transportation costs, and are limited in their ability to supply energy far from their source. A general rule of thumb is that a boiler or power plant in which heat or efficiently transmittable electricity can be made should be located within 50 miles to be economically feasible, although gasification technologies promise to extend that number.

Developing the market for non-fuel-related products from so-called bio-refineries is viewed as a critical component that could accelerate the use of biomass for energy. Many consumer and industrial products that could be made from renewable bioproducts currently come from petrochemicals. Both plant and petroleum molecules can be processed to create the materials to manufacture consumer goods—including plastics, solvents, paints, adhesives, lubricants, inks, and drugs—yet plant resources currently provide only about five percent of manufacturing inputs. The production of bio-based products—including textile fibers, polymers, adhesives, lubricants, soy-based inks, and others—is estimated at 12.4 billion pounds per year out of a total in the hundreds of billions of pounds, a fact which demonstrates enormous potential for growth.

Ethanol production from corn grains has a net energy balance of 1.34, or one energy input ultimately yields 1.34 more energy, with the most efficient farms surpassing a 2.0. Cellulosic bioethanol from dedicated energy crops project an energy balance of 2.62, so from such agricultural waste as corn stover, the figure could surpass 5.0, due in large part to burning lignin for the production of electricity. The production of biodiesel from soybeans has a net energy balance of 3.2 because of lower requirements for fertilizer and processing.

## Regulatory Drivers

Federal and State incentives exist that could improve overall market penetration and accelerate the growth of biomass fuels. Effective in 2005, producers of fuel ethanol receive a tax credit of $0.51 and biodiesel receives a tax credit of between $0.50 to $1.00 per gallon, depending on feedstock. In addition, 36 States provide some other incentives for the production of ethanol. The Farm Service Agency/Commodity Credit Corporation Bioenergy Program (USDA) supports the increased production of biofuels and has a ceiling of $150 million per year. The Value-Added Development Grant program (USDA) provides grants to agricultural producer ventures that work to develop new businesses to expand the market for agricultural products and the agency has $14M in grants available. The Farm Service Agency's Conservation Reserve Program (CRP), designed in part to protect the environment, takes marginal farmland out of service, which are potential sites for cellulosic biomass. In 2003, the CRP paid more than $1.57 billion in rental payments on 34 million acres.[56]

### *Wind Power*

Wind energy is the world's fastest-growing energy technology. In the U.S. today, wind power accounts for more than 6,300 megawatts of capacity.[57] California is home to more than 2,000 megawatts of this capacity, and Texas to another 1,300.

## Fuel Resource and Technology

A significant portion of the continental U.S. is amenable to wind production (see Figure 23). Wind resources are expressed in terms of wind power classes, from the lowest class, 1, to the highest class, 7. Researchers consider Class 3 winds with average annual speeds of 15 miles per hour strong enough for power generation. The most consistent winds are found in the Great Lakes region and from ocean breezes along the Eastern, Western and Southern coasts.[58] The potential electricity generation from wind in the U.S. through advanced wind turbine technologies is estimated at 10,777 billion kWh per year.[59]

## Technologies

Wind power is produced by converting the kinetic energy in the wind to mechanical energy and then to the generation of electricity. There are two types of modern wind turbines: the more common, horizontal axis type and the vertical axis design. Horizontal axis turbines come in either two- or three-blade configurations, while the vertical axis turbines are shaped more like an eggbeater. On modern turbines, microprocessors adjust blade direction and pitch to maximize power output in specific wind conditions.

The output of a wind turbine depends on the size of the turbine and the speed of the wind through the rotor. Wind turbines range in size from 50 kW to several MW. Most manufacturers of utility-scale turbines offer equipment in the range of 1.5 kW to 2.5 MW; 1.5 MW being typical. The larger turbines are grouped together to form wind farms for support of the electrical grid. Smaller turbines are used to power homes, pump water, and supply areas not served by the grid. Each turbine requires around 100 acres of space, but only occupies a 15-to-30-foot diameter at the base, which leaves room for farming and other activities.

56 National Commission on Energy Policy, *Ending the Energy Stalemate*, December 2004.
57 EIA, 2005.
58 "Evaluation of Global Wind Power," Cristina L. Archer, Mark Z. Jacobson, Stanford University, Stanford, California, 2005.
59 American Wind Energy Association, "Fact Sheet: Wind Energy, an Untapped Resource," at www.awea.org, accessed on March 15, 2006.

Onshore turbines for land-based wind farms come in various sizes, with rotor diameters ranging from about 50 meters to about 90 meters, and with towers of roughly the same size. A 90-meter machine with a 90-meter tower would have a total height from the tower base to the tip of the rotor of approximately 135 meters (442 feet). Small wind turbines intended for residential or small business use are considerably smaller, with rotor diameters of eight meters or less and mounted on towers of 40 meters in height or less.

Offshore turbines will have access to higher energy winds with lower turbulence. Europe has more experience with offshore wind farms. In comparison with the experience in Europe, however, offshore wind farms in the U.S. will have to contend with deeper waters and difficulties caused by wind, waves, and ice. Offshore turbine designs can have larger rotors because it is easier to transport large rotor blades by ship than it is by land.[60]

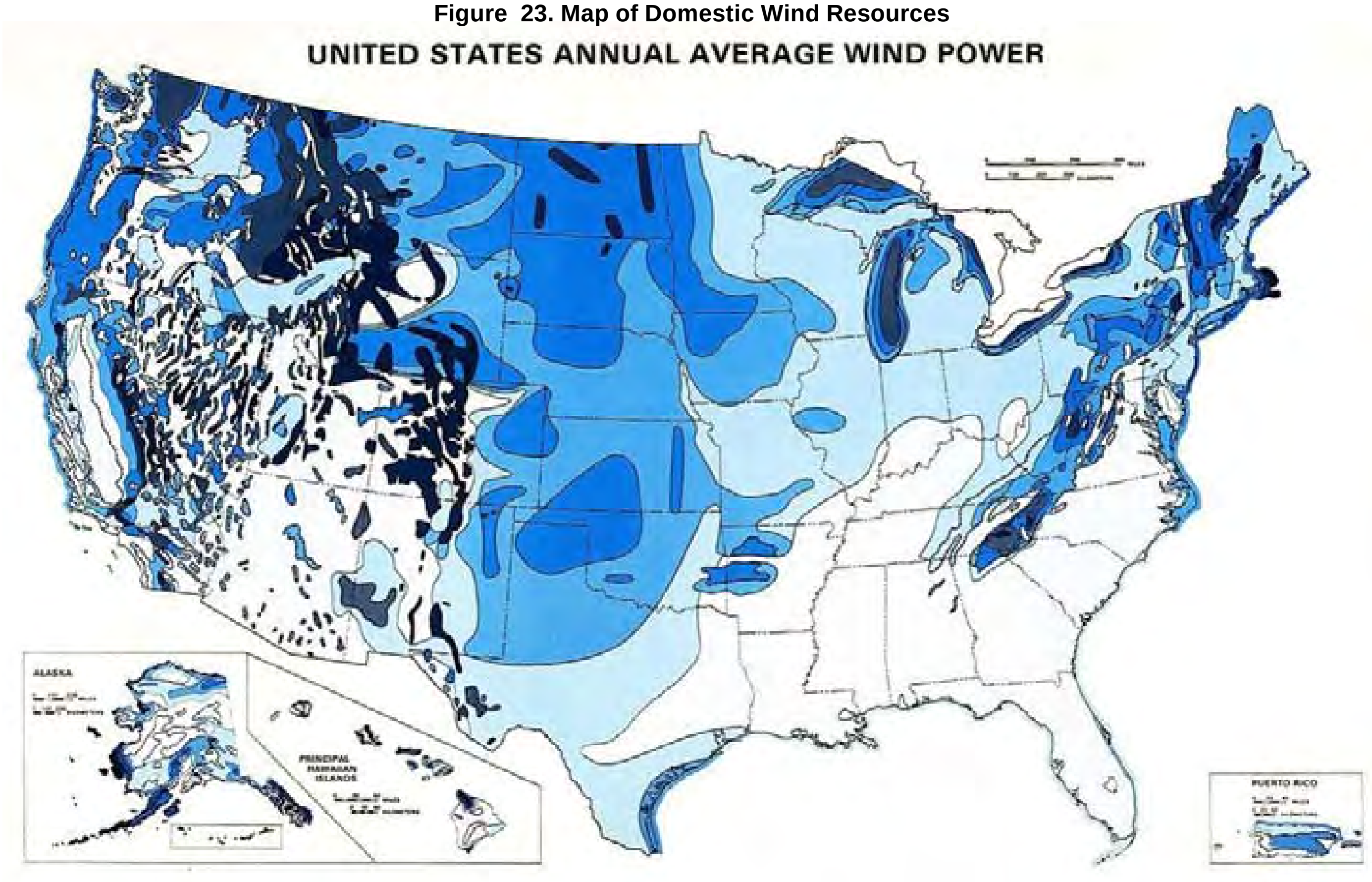
## Technological Developments

The major technology developments will be focused on reducing the cost of wind energy and improving low-wind-speed turbines. Another focus is on the development of the distributed generation aspect of small wind systems and the integration of larger systems into the electrical grid. Some forecasts project wind energy to be competitive with fossil fuels without subsidies by 2010. These forecasts are based on such improvements in wind production as larger wind farms and average turbine size.[61]

## Prices and Costs

Wind power has no fuel costs. State-of-the-art wind turbines are estimated to have the ability to produce electricity for less than $0.05/kWh,[62] with most estimates coming in at between $0.04 and $0.06/kWh. The size of the wind farm, the speeds of the wind, the finances of the project, and other factors account for differences in the prices of wind-generated electricity among the regions. Other factors that can influence the economics are the distance from the wind farm to demand, the availability of transmission and of land, and the matching of seasonal and daily production with demand. With regard to this last factor, the California Independent System Operator has been working with wind generators to put in place better tools for forecasting and scheduling and offering a special monthly settlement process to allow wind generators to make up for bad wind days.

**Figure 23. Map of Domestic Wind Resources**




*Source:* U.S. DOE, *EERE Wind Power Program, 2005*

60 Danish Wind Energy Association, www.windpower.org, May 2005.

61 National Renewable Energy Laboratory, Wind Program, 2005.

62 Danish Wind Energy Association, www.windpower.org, May 2005.

Overnight capital costs are projected to be around $1,200/kw in 2005 dollars, or around $1.5 million for the average turbine. Estimates for fixed operating cost range from $19 to $25/kW-year. These figures vary greatly depending on wind levels in the region. Offshore platforms, which are touted because of their ability to provide as much as 50 percent more output than inland units, also face somewhat higher capital costs: $1,390/kw in Germany and $1,800/kw in Sweden.[63]

## Benefits and Challenges

Wind power provides a clean source of energy that requires no fuel and produces no emissions. Wind is largely unaffected by price changes in fuel or disruptions in supply. Due to its modular nature, capacity is relatively easy to increase. Although the U.S. wind resource is significant, only part of it can be exploited economically, because much of the resource is located far from demand and connecting to the grid is costly. Because of the intermittent nature of wind power, a considerable amount of attention has been focused on reserve capacity (additional resources needed to compensate when the wind is not blowing), and energy storage. A tax production credit allows wind to be competitive with other energy sources, and projections suggest the credit may not be necessary by 2010 as new designs become more efficient and cost competitive.

Environmental issues associated with wind power can be grouped into three areas: (1) impact on wildlife, (2) noise, and (3) visual and scenic impacts. The impact on wildlife involves primarily the deaths of birds and bats. Modern turbines are designed to reduce this occurrence through the elimination of perching opportunities and slower rotation of the blades. Improved attention to siting also reduces this concern. Two types of noise are involved: mechanical and aerodynamic. Mechanical noise is produced by the turbine; aerodynamic noise is produced by the blades passing the tower. Improved engineering in modern turbines addresses these impacts. Visual impacts are significant because of the size of the towers, but the impacts are more subjective. Some localities treat wind turbines as eco-tourism attractions, while other areas have resisted wind power as visual blight on the natural environment.[64]

63 *Ibid.*

64 The two most noteworthy examples of this are in Toronto and Massachusetts. The city of Toronto has embraced wind power and allowed the construction of a large turbine in the most visible section of their waterfront. Contrarily, Cape Cod homeowners have waged vigorous opposition to a Cape Wind project that would develop a farm of 130 off shore turbines in the Nantucket Sound.

## Regulatory Drivers

At the Federal level, starting with the 1992 Energy Policy Act and extended in the Energy Policy Act of 2005, the Federal government provides a Production Tax Credit (PTC) of $0.019/kWh that is applicable to the first ten years of a facility's operations. In addition, a number of States have financial incentives to encourage wind power. For example, California's Existing Renewable Facilities Program, designed to help support in-state existing renewable technologies, has allocated $70.2 million to help wind energy generators to compete in a competitive market. California's New Renewables Program has provided $38.6 million in fixed production incentives, with another $65.4 million in the pipeline. Also, wind power qualifies as a renewable resource under State-mandated Renewable Portfolio Standards.

### *Solar Power*

Solar energy represents one of the largest opportunities for growth in clean energy. While the potential is enormous, the challenges remain significant.[65]

## Fuel Resource and Technology

Terrestrial solar insulation on the earth at any given location is a function of time of day, time of year, latitude, and atmospheric haze. The closer to the equator and the drier the climate, the more solar energy resource is available. Figure 24 identifies the best locations for the generation of solar power in the U.S.

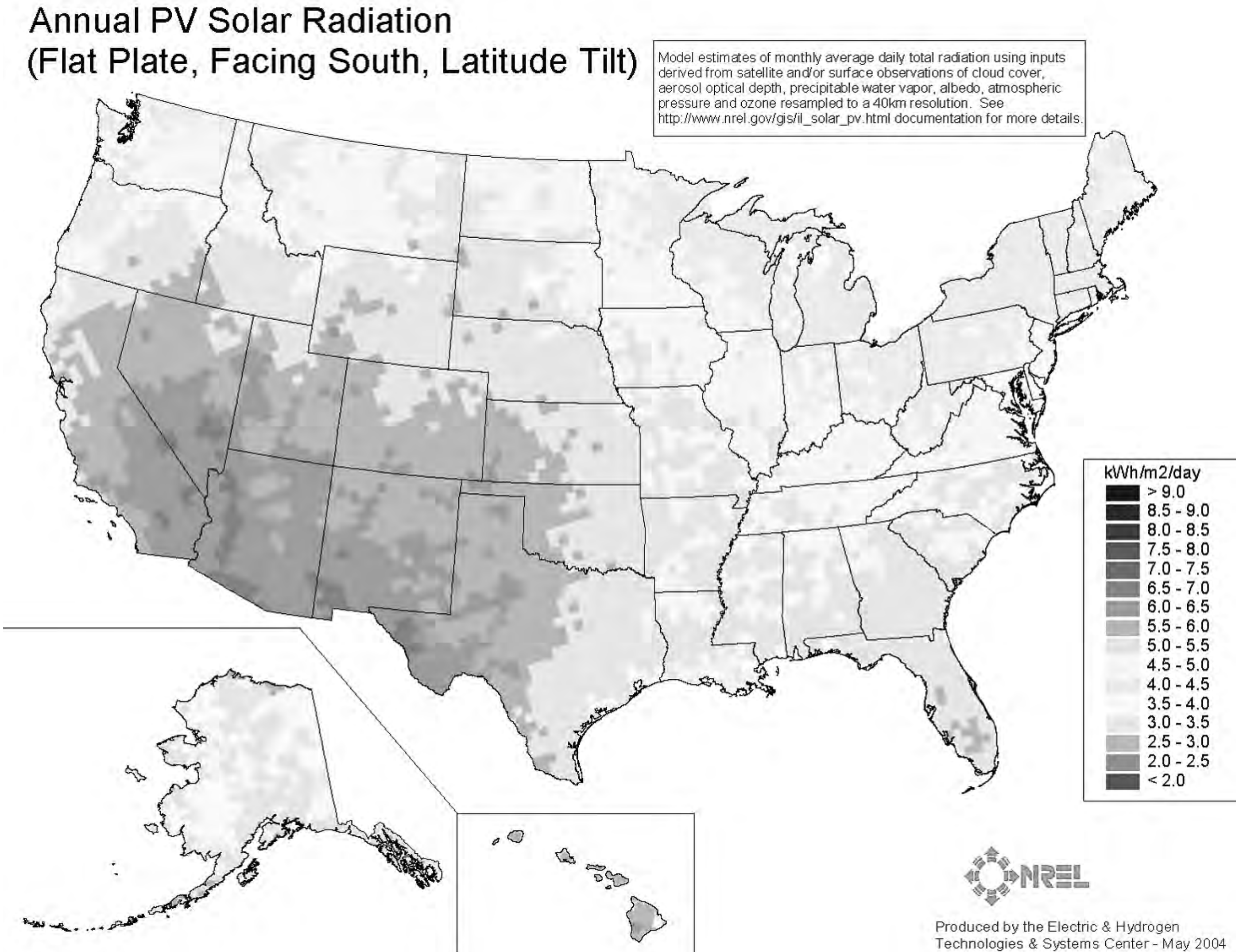
## Technologies

***Photovoltaic*** – A photovoltaic cell consists of semi-conducting material that absorbs the energy in sunlight to make the semiconductor's electrons flow to produce electricity. These cells are arranged into modules of about 40 cells that are mounted in an array that consists of about 10 modules, a common rooftop configuration. Crystalline cells are efficient, expensive, and material intensive, but thin film technology uses layers only a few micrometers thick, which can be integrated into rooftop shingles, roof tiles, building facades, windows, skylights or atria. These cells use about one percent of the raw material (silicon) compared to wafer-based solar cells, which leads to a significant drop in price per kWh.

Two new PV technologies are now near commercial deployment that have the potential to dramatically reduce the cost of photovoltaics: thin-film organics and nanotechnology. Organic (polymer-based) solar cells, while not yet as

65 For a more thorough overview of solar technologies, please see the CECA website, www.deforum.org.

**Figure 24. Map of Domestic Solar Resources**




*Source:* NREL, 2005

efficient as those based on silicon, are much less expensive to manufacture and are expected to be on the market within the next year for powering military electronic devices and commercial devices such as calculators. Improvements in efficiency and durability, prerequisites for rooftop power applications, are under development with the potential for efficiencies near current silicon-based technologies at 50 percent or less of the current cost. Technology proponents promise nanotechnology-based cells with efficiencies similar or greater than existing silicon cells at one-third the cost by 2007, with the potential to provide electricity at $.05/kWh well within the 2025 timeframe.

***Solar Thermal Power*** – Electricity can be produced by concentrating solar power through the use of mirrors, which creates a high-intensity heat source and produces steam or mechanical power to run a generator. Three types of concentrated solar power exist: parabolic trough, dish/engine, and power tower. The parabolic trough uses a U-shaped mirror to heat a fluid in a centrally located pipe that then is used to make steam. The dish/engine concentrates solar energy in a setup similar to a satellite dish with a Stirling engine at the focus to create mechanical power. The power tower concentrates sunlight to a receiver at the top of a large tower, using acres of mirrors and molten salt as a working fluid.

***Solar Thermal Heating*** – Solar thermal heating collects the heat energy in non-concentrated sunlight to preheat boiler air, to heat building spaces, domestic water, or swimming pools. The heat from a solar collector can even be used to provide energy for cooling a building.

***Passive Solar*** – Buildings can be designed for passive solar heating using such construction aspects as large, south-facing windows and materials that absorb and store the heat of the sun into the floors and walls. The floors and walls then will heat up during the day and slowly release heat at night. Design elements include sunspaces (greenhouse) and Trombe walls, which capture heat into structural surface and release it into the space at night.

## Prices and Costs

Solar power has no fuel costs. Current costs range from $0.2055/kwh for industrial use to $0.26/kWh for commercial use and $0.37/kWh for residential uses.[66] The industrial price index is based on a 500-kW, flat-roof-mounted solar system connected to the electricity grid, excludes back-up power, and includes system integration and installation costs. The commercial index is based on a 50-kW, ground-mounted system that is used for distributed energy and is connected to the grid. Similarly, it excludes back-up power and includes system integration and installation costs. Residential price index is based on a 2-kW peak system, roof-retrofit-mounted, connected to the grid with battery back-up to allow the system to operate during times of electricity downtime and includes system integration and installation costs. Meanwhile, solar thermal power costs range between $0.09 and $0.13/kWh in California and other areas that have exceptional solar resources.

The cost of a photovoltaic system varies based on the configuration. About half of the cost is for the modules, and the inverter with array support structures, electrical cabling, equipment, and installation account for the rest. Costs estimates of solar electric systems are in the range of $8 to $12/watt for a residential system. DOE estimates the installed cost of a two kW system (a typical residential configuration) at about $24,000 and a 30 kW commercial system at $270,000.[67] Capital cost estimates of a utility-size configuration of five MW are around $3,900/kw, with fixed operating and maintenance costs of $14.80/kw-year.[68] Overall, capital costs have declined an average of two percent per year for photovoltaic cell systems and 1.5 percent per year for solar energy facilities. Flat plate water heating systems range in price from about $2,000 to $4,000 installed for residential systems (for 40 to 80 gallons per day usage) and $2,000 to $50,000 for commercial systems (for 40 to 1700 gallons per day usage).[69]

## Benefits and Challenges

Since photovoltaic systems do not operate continuously, it is more common to think of these systems as supplemental resources that temporarily displace dirtier forms of electricity and accompanying emissions. Photovoltaic systems have no moving parts and are virtually maintenance free. Photovoltaic power, in combination with batteries or other energy storage systems, is practical for remote areas in which grid connections are not economically feasible. In addition, solar power can serve as a peak shaver on buildings in which its maximum supply coincides with peak demand, such as during the summer.

Solar energy is regional, weather dependent, and somewhat seasonal, and therefore economics are regional as well. Solar power has a low capacity factor—around 15 percent for photovoltaic—because of cloud cover and darkness at night. Arid regions like California can reach a capacity of 20 percent for photovoltaic systems and 35 percent for thermal power. The environmental problems of solar power center around material and energy resources requirements for manufacture, and the impact on land use. Central station solar power requires between five and 17 acres per megawatt, and is only practical in certain climates.[70] The manufacture of silicon-based photovoltaics requires substantial energy, and traces of heavy metals also may be generated.

## Regulatory Drivers

A number of financial incentive programs are designed to support the production of solar power. At the Federal level, the Energy Policy Act of 2005 provides an investment tax credit of 10 percent for businesses as well as accelerated depreciation on equipment that uses solar energy to either generate electricity, heat or cool, provide hot water, or provide process heat. A number of States have financial incentives to establish solar power. For example California has a Solar Tax Credit of 15 percent of net cost of purchasing and installing a solar system up to 200 kW in capacity.

In addition, solar power qualifies as a renewable resource under State-mandated Renewable Portfolio Standards. Finally, the Renewable Energy Production Incentive (REPI) program, authorized under the Energy Policy Act of 1992, offered a payment of $0.018/kWh payment for the production of solar plants prior to September 30, 2003, for facilities owned by nonprofit cooperatives or State/local governments.

Net metering regulations are a significant regulatory issue for solar power. 40 States now have net metering laws in place. While each State law is unique, they all allow excess generation from the resource to be "sold back" to the grid. This is significant because solar electricity systems are most often installed as supplemental resources to grid. Designers can install solar arrays that are larger than needed so that

66 Solarbuzz Solar Electricity Index, at http://www.solarbuzz.com/SolarPrices.htm, accessed on June 1, 2005. Calculations are based on a monthly survey of more than 100 companies (80% in the U.S.) that sell solar electricity equipment and systems. Calculations also consider total kilowatts generated and financing charges to develop a retail price index. Prices do not include any solar rebate or incentive programs.

67 Department of Energy "What does it cost? Residential," San Diego Regional Office, 2004.

68 Booz Allen Hamilton, 2004 Coal-Based Integrated Coal Gasification Combined Cycle: Market Penetration Recommendations and Strategies,. R. W. Beck estimates capital costs at $5,000/kw for solar thermal power and $6,000/kw for photovoltaic (sensors and actuators for tracking the sun add an additional 5 to 10% to the total cost).

69 Federal Energy Management Program Solar Water Heating Technology Alert.

70 R. W. Beck makes an alternate estimate of four acres/mw for dish solar thermal power, five for trough, eight for tower, and 10 for photovoltaic.

when the solar resource produces excess electricity, the meter will turn backwards, further reducing costs.

## Geothermal

There are two types of geothermal energy technologies: one that uses the steady-state temperature of shallow earth as a heat source or heat sink, also known as geoexchange and used primarily for space and water heating, and one that uses superheated rock, typically found much deeper, used for direct use heating or power production. Geothermal energy is primarily a regional resource and the best resources are located in the Western part of the U.S., including Alaska and Hawaii (see Figure 25).

## Fuel Resource and Technology

By far, the largest amount of electricity production from geothermal resources takes place in California, with 1,633 MW generated at four plants, with another 242 plants planned. Total generation from geothermal electricity plants in the U.S. is 2,300 MW.[71] California's Geysers Power Plant is the largest geothermal power plant in the world. The direct use of geothermal resources represents a much larger use of energy in the U.S. and accounts for 3,858 GWh/year. In these applications, geothermal energy provides heat to both individual buildings and district heating in California, Oregon, and Idaho. In addition, geothermal power is used in greenhouses and aquaculture facilities in a number of Western States.

It is estimated that the Western U.S. has the capacity of approximately 13,000 MW of geothermal energy. Of that, geothermal industry experts agree that 5,600 MW are viable for commercial development within the next 10 years.[72]

## Technologies

Geothermal resources are used both in a configuration of electric power plants and directly for hot water and for heating and cooling. Each application utilizes the technologies in very different ways.

*Electricity Generation* – Wells can be drilled into underground reservoirs for the generation of electricity. Three types of geothermal power plants are in operation today. Dry steam power plants use geothermal steam to drive a turbine. Flash steam power plants spray hot water into a low pressure tank to rapidly vaporize (flash) it and then drive a turbine. Binary-cycle power plants use a heat exchanger between the geothermal water and working fluid.

*Direct Use of Geothermal Energy* – Near-surface geothermal water can be used directly for such purposes as heating buildings, growing plants in greenhouses, drying crops, and heating water at fish farms. It also has applications in several industrial processes like pasteurization.

Geothermal heat pumps use the relatively steady temperature of shallow (5 to 300 feet deep) ground or water to heat and cool buildings. The system includes pipes buried in the shallow ground near the building, a heat exchanger, and ductwork into the building. In winter, heat from the relatively warmer ground goes through the heat exchanger into the house. In summer, hot air from the house is pulled through the heat exchanger into the relatively cooler ground.

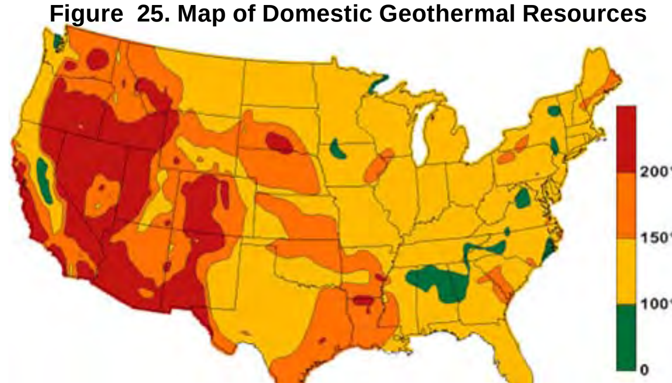
*Technology Developments* – Beneath the entire surface of the earth, at depths of three to five miles, are hot, dry rock resources. Technology is under development to access the energy in these rocks by the injection of cold water down one well, circulation of that water through the hot, fractured rock, and recapture of the heated water through a second well.

## Prices and Costs

Like wind and solar power, geothermal resources themselves have no fuel costs. Depending on their location, however, leasing fees may be required to access the resource. Power sold from the Geysers Power Plant costs from $0.03 to $0.035/kWh. Prices around $0.05/kWh would be more likely to be required from a new plant, however, with a binary plant slightly higher ($0.058/kWh). Geothermal power is used for base load and therefore should be able to gain a higher price than such other, more intermittent power sources as wind or solar power.

The costs for geothermal power plants typically are high for installation, low for operation and maintenance, and zero for

**Figure 25. Map of Domestic Geothermal Resources**




*Source:* U.S. DOE, *Geothermal Technologies Program 2005*

71 NREL, "The Status and Future of Geothermal Electric Power", NREL/CP—550-28204, August 2002.

72 Western Governors Association, "Geothermal Task Force Report: Executive Summary," January 2006.

fuel over the life of the plant. Capital costs for geothermal power plants include land, the drilling of exploratory and steam field wells, and physical plant, including buildings and power-generating turbines. Capital expenditure estimates for flashed steam power plants of five MW or larger are between $1,500 and $2,000/kW, while the estimates for binary plants are between $2,000 and $2,500/kW.[73] Smaller plants (less than one MW) are estimated at between $3,000 to $5,000/kW. Operating and maintenance costs range from $0.01 to $0.03/kWh. Availability is greater than 90 percent; running at 97 percent or better increases the cost of maintenance. Table 19 presents the geothermal cost factors.

The operating and maintenance costs for geothermal power plants range from $0.015 to $0.045/kWh, depending on the frequency with which the plant runs. Geothermal plants typically run 90 percent of the time, but they can be run as much as 97 or 98 percent of the time. High run times are found whenever contractual agreements pay high prices for power. Higher-priced electricity justifies running the plant at high-capacity factors because the resulting higher costs of maintenance are recovered. Table 20 provides costs of geothermal operating and maintenance by plant size. Large plants tend to have lower costs for operation and maintenance because of economies of scale.

Geothermal heat pumps cost between $2,500 and $3,500 per ton of capacity (a ton of capacity would fulfill the heating needs of between 450 and 550 square feet of space, depending on the climate). This first cost can be between 50 and 100 percent more than conventional heat pump systems. EPA estimates energy savings over conventional systems at between 30 to 70 percent on heating and 20 to 50 percent on cooling costs.

## Benefits and Challenges

Geothermal power plants require a small footprint—between one and eight acres per kW—and no storage is necessary. It is virtually free of emissions (some open-loop systems emit small amounts of $CO_2$, hydrogen sulfide ($H_2S$), and other emissions). The $H_2S$ is the largest concern because it produces a sulfur smell. Proper disposal of produced fluids is another concern. Geothermal power has an availability rating of 90 percent and can go higher based on demand. This makes it an attractive renewable fuel source for reliable and high quality base load electricity.

## Regulatory Drivers

The California Geothermal Resources Act of 1967 started to frame U.S. policy for geothermal power. This legislation was followed by the Federal Geothermal Steam Act of 1970, which was amended in the renewable energy title (Title II) in the Energy Policy Act of 2005.[74] These Acts were designed to

**Table 19. Geothermal Power Direct Capital Costs**

| (U.S. $1999 /KW installed capacity) | | | |
|---|---|---|---|
| **Plant Size** | **Component** | **High-Quality Resource** | **Medium-Quality Resource** |
| **Small plants** | Exploration | $400–$800 | $400–$1,000 |
| **(<5 MW)** | Steam field | $100–$200 | $300–$600 |
| | Power plant | $1,100–$1,300 | $1,100–$1,400 |
| | **Total** | **$1,600–$2,300** | **$1,800–$3,000** |
| **Medium plants** | Exploration | $250–$400 | $250–$600 |
| **(5–30 MW)** | Steam field | $200–$500 | $400–$700 |
| | Power plant | $850–$1,200 | $950–$1,200 |
| | **Total** | **$1,300–$2,100** | **$1,600–$2,500** |
| **Large plants** | Exploration | $100–$400 | $100–$400 |
| **(>30 MW)** | Steam field | $300–$450 | $400–$700 |
| | Power plant | $750–$1,100 | $850–$1,100 |
| | **Total** | **$1,150–$1,750** | **$1,350–$2,200** |

*Source:* R.W. Beck, 2003

**Table 20. Geothermal Operating and Maintenance Costs by Plants Size (U.S.$/kWh)**

| Cost Component | Small Plants (<5 MW) | Medium Plants (5 - 30 MW) | Large Plants (> 30 MW) |
|---|---|---|---|
| **Steam field** | 0.35–0.7 | 0.25–0.35 | 0.15–0.25 |
| **Power plants** | 0.45–0.7 | 0.35–0.45 | 0.25–0.45 |
| **Total** | 0.8–1.4 | 0.6–0.8 | 0.4–0.7 |

*Source:* R.W. Beck, 2003

73 U.S. DOE, *Geothermal Energies Program*, available at www1.eere.energy.gov/geothermal, accessed on March 14, 2006.

74 While the Energy Policy Act of 2005 authorized funding for geothermal resources, the President's FY 2007 budget zeros out the program altogether (from $23 million to zero).

define and characterize geothermal resources and to deal with the relationship of geothermal resources to other resources and ownership rights. In addition, geothermal resources found on public lands are subject to leasing requirements of the Department of the Interior. Finally, geothermal projects have to abide by State requirements designed to manage the resources properly.

## 6.5 Energy Efficiency

Certain concepts should be addressed at the outset of a discussion on energy efficiency. This section will begin with an explanation of terms, a discussion of the potential impact of energy efficiency, and the correction of a common misperception.

The distinction between energy "conservation" and energy "efficiency" in a policy related document centers on the concept of sacrifice. Technically, efficiency is the ratio of output to input, and therefore can be increased by increasing output relative to input. Conservation simply refers to a net reduction in input, so if less energy (water, money, etc.) has been consumed, conservation has been achieved, regardless of a change in output. In isolation, "energy conservation" typically means achieving less with less energy, implying a level of sacrifice, be it of comfort, service, or convenience. Energy efficiency typically means (1) doing the same by using less energy, implying net conservation with no sacrifice, or (2) doing more with the same energy usage, implying increased service with no net conservation. The different nuances of the term "energy efficiency" are explained to de-stigmatize "conservation," that it is a potential positive consequence of efficiency, especially in the context of an increase in projected demand and the analysis of energy efficiency as a fuel resource.

Furthermore, the rebound effect is real: when a device has a gain in energy efficiency, for example of 10 percent, that full 10 percent could potentially be conserved. Yet that efficiency gain (or a corresponding decrease in price) represents additional resources a consumer can spend, and a large proportion can be, and often is, spent on energy consuming activities. Hence, depending on the nature or application of the system or device, much of that potential energy savings can be consumed by additional use rather than conserved.

History has demonstrated that the largest impetus to moving towards a higher level of energy efficiency is a higher price of energy (especially relative to income). The greater the cost of fuels as power plant inputs, the more aggressively power producers increase the efficiency of their generation. The more expensive delivered energy (electricity, natural gas, gasoline, etc.) becomes, the more consumers will demand efficient energy consuming devices, and the more consumers will conserve. However, efficiency is often not viewed by the consumer as an end in itself, and standard of living and economic growth typically trump energy efficiency in the public debate. In general, what is best economically for a consumer is inexpensive energy. Therefore, it is a delicate balance to achieve the primary goal of inexpensive energy for the consumer, while also attempting to achieve the goals of lower energy demand and consumption, higher energy efficiency, and environmental protection.

Finally, it is a common misperception that GDP and energy consumption are directly linked, and must increase or decline together. Data from WWII through the 1980s seemed to show a causal link between per capita GDP (income) and per capita energy consumption. However, for much of this period the real price of energy declined which encouraged consumption and decreased the incentive for technical innovation towards efficiency. Certain lessons come from the analysis of the effect of energy prices. One is that market adjustment to prices takes place over the long term, due in large part to equipment replacement cycles and the pace of technological innovation. Secondly, comparison between energy intensity in the U.S. and other countries is difficult, due to such factors as the size of the country, infrastructure, climate, and cultural preferences. There is a positive relationship between economic growth and energy consumption, since labor, capital, energy, and other factors are economic inputs with varying levels of cost and substitutability between them. But the idea that the link is causal, and therefore a reduction in energy consumption will be negative for the economy, is a widespread fallacy which influences policy.

### Fuel Resource and Technology

The fuels analyzed to this point focused on increasing supply, yet energy efficiency is a significant resource which can be tapped in meeting the projected energy demand, in maintaining economic growth, and in protecting the environment. Included are the concepts of both efficiency and conservation. Efficiency gains can account for some of the projected increases in demand, in the form of increased services or work. Efficiency gains with a net conservation effect would directly lower the energy supply necessary to provide services and economic growth.

Measuring the impact of energy efficiency and its related costs is a difficult challenge. Change in energy use is driven by several intertwined and often inseparable factors, efficiency being only one. Other material influences on energy use over time include weather, assumptions about the behavior of consumers, economic structure, and technological innovation.

## Energy Intensity

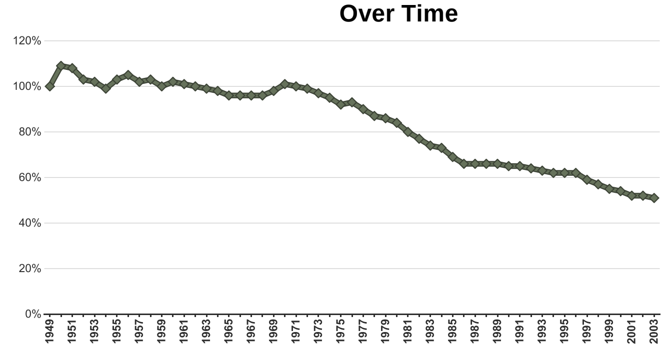
In its simplest form, energy intensity is the ratio of energy consumption to demand. A comprehensive approach to energy intensity starts with the broadest indicators of energy use and demand, and as such measures change over time, changes in behavior, weather, structure, and energy efficiency are captured. This top-down approach strips away the other effects until only energy efficiency remains, and the change over time is utilized to gain insight into energy efficiency trends. An ideal measure of energy intensity should identify or remove as many of the factors unrelated to energy efficiency as practicable, from both the numerator (energy consumption) and the denominator (demand indicator). The energy consumption figure, the amount of energy delivered to an end user, can either account for generation, transmission, and distribution losses (primary energy), or not adjust for it (site energy). Typical energy intensity inputs are the macroscopic energy figures reported by EIA for energy consumption, and GDP for a demand indicator. Figure 26 illustrates changes in energy intensity in the stationary energy sector since 1949, and although energy intensity in 2003 is less than half of what it was in 1949, only a portion of this reduction can be attributed to efficiency gains.

## Technologies

From a technical point of view, one basic method to increase energy efficiency in any thermal process, such as process steam, HVAC, or power production, is to capture more heat from the fuel, or to put more of the heat to useful work. Combined cycle plants utilize this concept, by capturing the lower energy waste heat and converting it into useful work. The second cycle must also reject waste heat, and it is possible to add a third cycle, but the design approaches the thermodynamic limit, and relatively tiny increases in efficiency require substantial investment in equipment. This is analogous to the law of diminishing returns in economic theory.

The largest stationary consumer of fuels is buildings, and the largest opportunity for improving energy efficiency in buildings is in lighting. Space conditioning represents 45 percent of residential energy consumption, and combined with building envelope, represents an enormous opportunity in efficiency in HVAC equipment, control systems, insulation, and glazing (window materials). The residential and commercial marketplace is flush with technologies which are both effective and economic, but market penetration of new technologies and construction practices lags adoption in other market spaces. A dramatic adoption of current technologies in new construction would not necessarily translate into dramatic energy demand reduction, because housing stock turnover is below three percent annually.

**Figure 26. Energy Intensity (stationary) Percent Change Over Time**




*Source:* EIA, *Annual Energy Outlook 2005*

When designing energy efficiency into a building or device, it is much more effective to have a machine or system remove the element of human decision from the operation by incorporating, for instance, a photocell or occupancy sensor on a light switch, than to rely on people to be diligent in conserving, and the results can be predicted better as well. The integration of energy management control systems into HVAC, lighting, and other systems provide a large opportunity to increase the energy efficiency of buildings. Whole building design practices involving concepts of sustainability, passive lighting (daylighting) and space conditioning (geothermal), and energy-producing technology attached to buildings (renewables), represent the next level of energy consumption reduction potential for buildings.

## Project Implementation and Perceived Benefits

Internal investment decisions are typically based on their return on investment (ROI), and projects are typically evaluated on a net present value (NPV) basis. Projects are prioritized or face a go/no-go decision based on NPV, ROI, the life of the project, and other factors such as risk. However, energy efficiency projects at for-profit firms tend to be evaluated somewhat differently than other capital investments. Instead of using NPV, projects or individual measures are typically evaluated in terms of simple payback which adversely affects the attractiveness of efficiency projects. Simple payback is a less sophisticated financial benchmark, which does not take into account a discount rate (time value of money), the value of intangibles like lowering risk and mitigating the volatility of energy prices, and all benefits after simple payback has been achieved are ignored. The estimated lifecycle term for equipment or measures is usually conservative compared to what is found in the marketplace, and evaluating projects via simple payback favors very short term or low risk projects, therefore penalizing energy efficiency projects which might be otherwise viewed as attractive or acceptable.

Energy efficiency projects therefore seem to face a higher internal rate of return (IRR) or hurdle rate than other projects. Empirically, nearly 80 percent of firms have a simple payback threshold of less than two years, and mean and median payback threshold of 1.4 and 1.2 years, which translates into a discount rate of about 70 and 80 percent, respectively. Although they ought to be proportional, project costs have about twice the effect on project adoption as changes in energy prices. Motor systems projects are the most attractive type of project, followed by combustion systems, buildings, operations, then thermal systems, and electric power projects are the least attractive. However, the risk that even a proven technology does not perform as designed can be a strong deterrent. These findings suggest that policy mechanisms to reduce costs (e.g., tax incentives at the implementation stage) would be more effective in the short term than price mechanisms, but price mechanisms would provide the continuing incentive over the long term. They further suggest that incentives that lower project risk, provide loan guarantees, or provide design assistance, may be receptive in the marketplace.[75]

## Prices and Costs

***Evaluation of Programs***[76] – Quantifying the cost and effectiveness of energy efficiency programs is difficult for a variety of reasons. Defining the baseline of energy efficiency that would occur naturally in response to price and technical innovation versus what has occurred as a result of specific programs is a complex task. When multiple programs may have influenced the same outcome, double counting may be an issue. A further complicating factor is that most of the information on either the costs or the benefits comes from the program itself, rather than an independent agency. In general, measuring and accounting for all the pertinent costs and all the pertinent benefits, and developing an objective, quantitative evaluation of such information, is very difficult.

There are various energy efficiency programs which can serve a similar function as technologies for the other fuels. These aspects are: codes and standards (buildings, equipment, appliances, etc.); demand side management (DSM) programs; voluntary or informational programs; management of government energy use; and research and development programs.

***Codes and Standards*** – Building codes directing certain energy efficiency features or construction practices have been in existence since before the early 1970s. Minimum standards for consumer appliances, as well as commercial and industrial equipment and lighting, have been in place at various levels since the early 1980s. Resources for the Future estimates that the Federal government has spent $61 million dollars in appliance efficiency efforts from 1979 to 1993, and that 1.2 quads of energy consumption was reduced as a result of Federal programs in 2000.[77] By some estimates, appliance and equipment standards and building codes had reduced national peak electricity demand by 20,000 MW and saved energy users more than $50 billion by 2000.[78]

***Demand Side Management*** – Utilities have instituted load management and conservation efforts directed at consumers in order to help match generating capacity to consumption. A combination of financial incentives and educational efforts to encourage the purchase of efficient equipment or to shift consumption to off-peak periods was successful early on. Resources for the Future estimates DSM savings of 0.6 quads annually. In States that moved to restructure their electricity markets, competition caused many utilities to slash their DSM programs.

***Informational or Voluntary Programs*** – Programs designed to encourage pure conservation (without efficiency gains) are usually met with moderate or short term results at best, and resistance to them at the political or implementation level is typically proportional to the level of sacrifice. However, programs designed to encourage energy efficiency or to simply cut waste, which do not require sacrifice, do not suffer from the same resistance. Efforts which are informational are intended to overcome an ignorance of (or cultural predisposition against) energy efficiency and results are often proportional to level of marketing and price of energy.

One standout program is the EPA's Energy Star program, a voluntary labeling program jointly administered by the DOE, which encourages adoption of energy efficiency by giving publicity to the most energy efficient products, appliances, even buildings. The budget for this program averages about $50 million per year, and estimates for energy savings are 900,000 MMBTU or 0.9 quads.[79] There are also two DOE programs for voluntarily reporting and reducing greenhouse gas emissions, which are directly related to energy efficiency. The major program is referred to as Section 1605b, which reported reductions in greenhouse gas emissions for 1,705 projects in 2001, reducing 6.1 million tons of carbon equivalents from energy efficiency or conservation projects.

***Independent Review of R&D and Standards*** – Studies by Lawrence Berkeley National Laboratories (LBNL) and American Council for an Energy Efficient Economy

75 Soren T. Anderson and Richard G. Newell, "Information Programs for Technology Adoption: The Case of Energy-Efficiency Audits," Resources for the Future, September 2002.

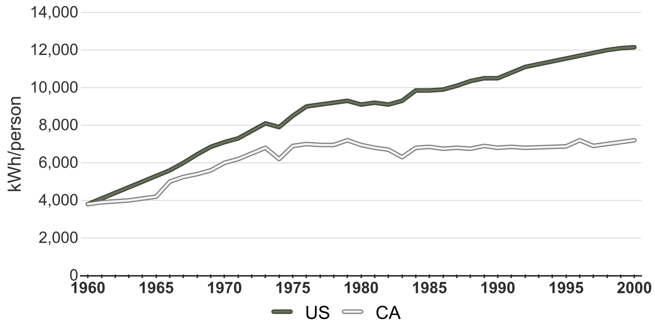
76 Kenneth Gillingham, Richard Newell, and Karen Palmer, "The Effectiveness and Cost of Energy Efficiency Programs," *Resources Magazine*, Fall 2004.

77 *Ibid*.

78 Jeff Schlegel, "New England Demand Response Initiative Framing Paper #4: Energy Efficiency," Schlegel & Associates, May 2002.

79 Kenneth Gillingham, Richard Newell, and Karen Palmer, "The Effectiveness and Cost of Energy Efficiency Programs," *Resources Magazine*, Fall 2004.

**Figure 27. Per Capita Electricity Consumption U.S. vs. California**




*Source:* EPRI, Gellings, 2003

(ACEEE) have examined building codes, appliance standards, and research and development programs for their impact on energy consumption and their cost-effectiveness. Their results are summarized below.

R&D, aimed at developing the science of energy efficiency, energy efficient products, and processes that the private sector would not pursue, as well as transitioning that technology to the marketplace, has been a key energy policy strategy of the Federal government and many States for several decades. In 2001, the National Academy of Sciences completed a study entitled "Energy Research at DOE: Was It Worth It?"[80] that reviewed DOE's energy efficiency and fossil energy R&D efforts over the 1978–2000 period. This study focused on six "big winners" and found that these six programs delivered a cumulative energy savings of almost five quads over a five year period (Federal R&D was only given credit in the study for the first five years of savings; the assumption being the innovations would have been delayed five years without Federal support) with a net cost savings of $30 billion. While R&D investment in these successful programs was approximately $400 million, total Federal energy efficiency R&D expenditures for the period of the study were in the $4-$5 billion range.[81] Including the total amount of R&D expenditures significantly reduces the return on investment. This highlights the promise and problem with R&D – one cannot accurately predict success or magnitude of impact, i.e., ROI of R&D expenditures in advance. However, a well-designed technology development portfolio approach can minimize risks and maximize yields from R&D investment dollars.

In California, as seen in Figure 27, constant per capita energy consumption has resulted from a combination of strong pollution controls, progressive efficiency standards, and the rise in energy prices. Consumption has remained constant during a period of strong economic growth in California while the rest of the country's per capita energy consumption continued to increase.

Building energy codes that mandate construction standards that result in more energy efficient homes and buildings, have also been an important policy strategy since the 1970s and it is important to understand their impacts. ACEEE attempted to estimate the national savings from building energy codes, presented in Table 21. For this analysis, they focused on code improvements developed in the late-1980s and early 1990s, improvements that have now been adopted in most States. New construction during the 1990s was examined and energy savings from use of these codes in those States that have adopted these model codes was calculated.

Overall, these codes are estimated to have reduced U.S. energy use by about 0.54 quads (537 tBTU) in 2000. It is estimated that a four-year payback period is required for commercial buildings and an eight-year payback for the residential improvements.

LBL and ACEEE both conducted extensive analyses of savings available from new appliance and equipment standards (see Table 22). Overall, LBL estimated that new standards on more than two dozen products can save more than 25 quads of energy on a cumulative basis by 2030, which is approximately 1.7 quads per year once the equipment stock turns over. Table 22 summarizes the results of both these studies for appliance energy efficiency standards.

In both studies, only those standards included are those that are cost-effective to consumers on a life-cycle cost basis. Overall, ACEEE found about 10 quads more of cumulative savings than LBL (38 percent higher savings). The end result is that either study shows annual savings potential from improved appliance standards on the order of one quad per year.

**Table 21. Impact of Energy Efficient Building Codes**

| | Savings in 2000 | | |
|---|---|---|---|
| | Electricity (TWh) | Fuel (trillion BTU) | Total (trillion BTU) |
| Residential: Adoption of 1992 CABO MEC or beyond | 16.0 | 127 | 306 |
| Commercial: Adoption of 90.1-1989 or beyond | 16.6 | 45 | 230 |
| **TOTAL** | **32.6** | **172** | **537** |

*Source:* ACEEE/Nadel, and LBL Studies, 2004

80 National Research Council, "Fossil Research: Was it Worth It? Energy Efficiency and Fossil Energy Research 1978-2000," National Academy Press: Washington, DC, 2001.
81 Steven Nadel, ACEEE and LBL Study, 2004.

**Table 22. Savings From New Appliance and Equipment Standards**

| End-Use | 30 Yr. Cumulative Savings (quads) | |
|---|---|---|
| **Residential** | **LBNL** | **ACEEE** |
| Gas space heating | 1.10 | 2.30 |
| Air conditioning | 0.10 | 5.77 |
| Refrigeration | 0.92 | 2.56 |
| Lighting | 1.90 | 6.65 |
| Water heating | 2.80 | 0.00 |
| Dishwashing | 0.13 | 0.46 |
| Motors | 0.48 | 3.40 |
| Misc. electronics | 4.50 | 2.29 |
| Subtotal | 11.93 | 23.42 |
| **Commercial/industrial** | | |
| Space heating | 0.71 | 0.86 |
| Air conditioning | 3.02 | 2.67 |
| Ventilation | 0.66 | 0.00 |
| Water heating | 0.25 | 1.47 |
| Lighting | 3.10 | 3.77 |
| Refrigeration | 4.52 | 0.76 |
| Office equipment | 1.55 | 0.00 |
| Miscellaneous | 0.00 | 0.18 |
| Distribution transformers | 0.00 | 2.29 |
| Subtotal | 13.81 | 12.00 |
| **TOTAL** | **25.74** | **35.42** |

*Source:* ACEEE/Nadel, and LBL Studies, 2004

## Regulatory Drivers

As the largest energy consumer in the U.S., the Federal government has a unique position in its ability to influence market behavior by its actions. Policies and practices that are successful in the Federal space often find their way into private firms' behavior, and energy efficiency is no exception.

Energy Savings Performance Contracts (ESPCs), authorized in 1992, evolved from earlier Congressional mandates to improve efficiency in Federal buildings and allow agencies to make energy-efficiency improvements to buildings and facilities. Contractors, referred to as Energy Service Companies (ESCOs), privately financed and installed capital improvements and energy efficiency measures, and in return received a share of the resulting savings over the term of contract, resulting in a zero or net positive budget impact for the agency, and at the expiration of the ESPC, the agency receives the total benefit for the life of the equipment or improvement. ESCOs also guaranteed a fixed amount of energy and cost savings and bore the risk of the installed measure's failure to produce the projected energy savings. Through 2004, more than 340 ESPCs have been awarded with a total value of approximately $1.6 billion in private sector investments. All have produced energy and cost savings.[82] Using the median costs and median savings for ESCO projects in the Federal and "MUSH"[83] (municipal/State governments, universities, schools, and hospitals) markets respectively, CECA calculates median costs of $0.12/kBTU saved for Federal and $0.21/kBTU saved for MUSH, which do not include significant non-energy savings in operations and maintenance or avoided capital cost benefits.

Data from State efficiency programs provide another reference point for the cost of energy efficiency. Massachusetts in 2001 reported that from 1995-1999 ratepayer-funded efficiency programs achieved savings at a conserved electricity cost of 3.7 cents/kWh (12.6 cents/kBTU).[84] For demand-side management, a study by the Natural Resources Defense Council (NRDC) found California programs to have an average cost of saved energy of 2.5 cents/kWh (8.53 cents/kBTU).[85]

82 Anthony Andrews, "CRS Report for Congress Energy Savings Performance Contracts: Reauthorization Issues," Congressional Research Service, September 1, 2004.
83 Nicole Hooper, Charles Goldman and Dave Birr, "The Federal Market for ESCO Services: How Does it Measure Up?" Lawrence Berkley National Laboratory, August 2004. Study found median ESCO project costs and savings to be $2.08/sqft and 18 kBTU/SF for Federal and $2.93/sqft and 14 kBTU/SF for MUSH.
84 Massachusetts Division of Energy Resources, "Energy Efficiency Activities 1999: A Report by the Division of Energy Resources," Spring 2001.
85 Natural Resources Defense Council, "Energy Efficiency Leadership in a Crisis: How California is Winning," August 23, 2001.

Taken together, the aforementioned programs have saved up to four quads per year, which represents nearly six percent of non-transportation consumption, or nearly eight percent of annual building energy consumption (see Table 23).

There is a large amount of State and Federal legislation intended to provide incentives to individuals and companies for undertaking energy efficient measures. Most recently, Title I of the Energy Policy Act of 2005 provided specific tax incentives for buying new Energy Star rated equipment and by increasing building energy performance standards. Surprisingly, the Act also includes a provision that will extend daylight savings time by three weeks under the assumption that more evening daylight hours will help reduce lighting expenses.[86]

## Benefits and Challenges

Energy efficiency has significant consumer benefits. The primary benefits stem from the fact that by acting on the demand side of the equation, it reduces the need for additional fuel resources and all their associated costs and challenges. There are none of the conflicts with consumer environmental interests associated with exploration, use, disposition, and emissions of conventional fuels. Energy efficiency supports consumer environmental goals in that it is an emissions-free means by which energy needs are met. Every MMBTU of energy avoided via efficiency has the avoided emissions value of whatever fuel source for which it is a substitute.

Energy efficiency alleviates strain on the grid during peak times, thereby reducing outages and supplanting the need for investments in transmission and distribution, as well as generation, thus benefiting the consumer in terms of reduced costs of electricity infrastructure. Energy efficiency gains typically persist indefinitely. If a level of service can be achieved via a more efficient method, a new standard is set, and the entire projected demand shifts downwards. Energy efficiency also benefits consumers since such resources are immune to large scale sabotage or other external harm. Basically, terrorists cannot attack an energy efficiency resource.

A major benefit of energy efficiency from a consumer perspective is that it results in lower energy costs and a hedge against energy price volatility and increases. In addition, consumers benefit from reduced operations and management costs and other non-energy related savings such as avoided capital costs associated with many efficiency measures. A related benefit is the fuel-price-reduction effect of energy efficiency deployment which reduces fuel demand and therefore exerts downward pressure on prices.

There are, however, theoretical, as well as economic limits to efficiency. The amount of waste heat that can be converted to useful work has practical limits. While additional efficiency might not require additional transmission lines, it might require a gasification cycle, an additional turbine, waste heat recovery equipment, or an HVAC economizer, all of which require additional costs, in both equipment and design. Increases in efficiency usually come incrementally and in response to technical innovation, which is difficult to accelerate without substantial R&D investments.

One of the largest limitations of energy efficiency is that it is directly related to the price of energy. In order to integrate efficiency into the economy at unprecedented levels, higher prices make the largest impact, yet that is undesirable from a consumer perspective. From a policy perspective, voluntary measures often yield poor results, and compulsory measures are often difficult to implement or enforce. Furthermore, setting specific efficiency standards may result in a minimum standard being viewed as the only standard stifling both innovation and/or demand.

## 6.6 Summary

The details discussed in this chapter combined with issues addressed in Part One of this report, make clear that great opportunities and challenges exist for all the fuels in the portfolio used to meet stationary energy needs. As this chapter illustrates, the fuels and technologies the U.S. has available are not perfect – they all have shortcomings when applied to the standards of the National Consumer Priorities (see Table 24). If not for price and intermittency, renewable

**Table 23. Energy Savings from Conservation Programs in 2000**

| Program | Energy Savings (Quads) | Costs ($M) | Cost Effectiveness ($M/quad) | Carbon Emissions (mm tCE) |
|---|---|---|---|---|
| **Appliance Standards** | 1.2 | $2,510 | $3,280 | 17.75 |
| **Utility DSM** | 0.62 | $1,780 | $2,890 (high of $19,640) | 10.02 |
| **Energy Star** | < 0.93 | $50 | - | < 13.80 |
| **1605b Registry** | < 0.41 | $0.40 | - | < 6.08 |

*Source:* Resources for the Future, *The Effectiveness and Cost of Energy Efficiency Programs*, 2004

86 Section 110. The provision includes the option to revert back to the 2005 daylight savings time schedule based on the impact – or lack of energy savings impact – of the additional three weeks.

energy resources would be ideal. If not for waste storage, nuclear energy may well be universally desirable. If not for greenhouse gas emissions, fossil fuels would be the best choice based on availability, costs, and convenience. The purpose of this chapter, therefore, is not simply to provide a complete fuels and technologies resource, but to provide policymakers with the tools needed to make difficult decisions a little easier.

**Table 24: Evaluating Fuels Against National Consumer Priorities**

| | Environmental Protection | Sustainable Economic Development | Affordable and Predictable Energy Services | Reliable and High Quality Energy Services | Public Safety | System Security |
|---|---|---|---|---|---|---|
| Coal | Requires control technologies for NOx, $SO_2$, and mercury emissions, which add to cost<br><br>Major source of carbon emissions<br><br>Requires significant amounts of water | Large resource base<br><br>Technology innovation focusing on emission reductions and alternative uses<br><br>Market for coal derived fuels<br><br>Developing country demand expanding | Coal prices have historically been low and stable. International competition could make prices more volatile.<br><br>Cost of electricity among the lowest. | With 250 years of domestic reserves, coal is a reliable source of electricity.<br><br>Good source of baseload electricity. | No unique public safety issues. | Domestic resource with large reserves. |
| Natural Gas | Significantly lower atmospheric emissions than other fossil energy electricity sources | Domestic resource supply constraints<br><br>LNG and nonconventional supply required constraints<br><br>LNG and nonconventional supply required | Natural gas prices among the most volatile<br><br>Rising prices affect consumers in electricity and heating/ cooling, as well as key industries | Price increases have mothballed a significant amount of generation and reduced capacity factors or others<br><br>Good for peak power generation | LNG safety concerns<br><br>Pipeline safety<br><br>Local explosion hazard | Increasing reliance on imports |
| Oil | Low-sulfur content in heating oil should reduce this issue<br><br>Storage tanks subject to leak inspections | Regionally significant<br><br>Refinery capacity constraints<br><br>Northeast Home Heating Oil Reserve is designed to dampen price spikes | Phasing out as a source of electricity<br><br>Heating oil prices follow crude oil and thus are affecting consumers | Phasing out as a source of electricity<br><br>Established distribution system for heating oil<br><br>Northeast Home Heating Oil Reserve can ensure supply during disruptions | No unique public safety issues | Increasing reliance on imports |
| Nuclear | Only thermal atmospheric emissions<br><br>Carbon friendly technology<br><br>Long term waste management issues remain | Plentiful fuel availability<br><br>New technologies designed to reduce cost, improve safety, and reduce spent fuel<br><br>Significant activity in Asia and Europe | Wide range of estimates for new nuclear plant costs thus, significant uncertainty on cost of electricity to consumers | Capacity factor increases have meant more electricity from existing plants<br><br>Good source of baseload electricity | Concerns over spent fuel transportation<br><br>Public concerns over uncontrolled releases and related evacuation plans | Proliferation and related terrorist concerns |

| | Environmental Protection | Sustainable Economic Development | Affordable and Predictable Energy Services | Reliable and High Quality Energy Services | Public Safety | System Security |
|---|---|---|---|---|---|---|
| Hydroelectric | No atmospheric emissions<br><br>Carbon friendly technology<br><br>Conflicts with fish management | Regionally significant<br><br>Expansion availability limited | Most inexpensive source of electricity<br><br>Susceptible to drought or low water conditions | Low water periods can reduce production | Dam safety<br><br>Dams designated as one of four key resources by DHS to ensure adequate safety and security measures in place | No unique system security issues |
| Biomass | Used with coal to reduce NOx emissions<br><br>MSW and animal waste biomass reduces waste management costs<br><br>Methane captured from MSW reduces greenhouse gas emissions<br><br>Carbon neutral | Use of dedicated energy crops holds promise of large energy resource base<br><br>Could be a new income source for farmers | Not widely used as electricity source<br><br>Cost of electricity is high<br><br>Used for process heat, particularly by forest and paper products industry | Not a major source of electricity other than as an additive with coal<br><br>Generally small scale or demonstration efforts to date | No unique public safety issues | No unique system security issues |
| Wind | No atmospheric emissions<br><br>Carbon friendly technology<br><br>New technology reduces bird kills and noise issues<br><br>Visual impacts are of concern | Regional resource<br><br>Fastest growing energy source<br><br>Significant overseas markets | Cost of electricity is competitive only in high wind areas.<br><br>Intermittent nature of wind requires backup generation | Intermittent nature of wind requires backup generation<br><br>Best wind areas are distant from electricity needs | No unique public safety issues | No unique system security issues |
| Solar | No atmospheric emissions<br><br>Carbon friendly technology<br><br>Central station power requires large areas | Regional resource<br><br>Another fast growing energy source<br><br>Nanotechnology holds promise of reduced cost<br><br>Innovative technology development | Cost of electricity is high<br><br>Best for niche applications | Best in niche uses<br><br>Individual PV applications would benefit from net metering | No unique public safety issues | No unique system security issues |

| | Environmental Protection | Sustainable Economic Development | Affordable and Predictable Energy Services | Reliable and High Quality Energy Services | Public Safety | System Security |
|---|---|---|---|---|---|---|
| Geothermal | No atmospheric emissions (except in open loop where there are small amounts of hydrogen sulfide)<br><br>Carbon friendly technology<br><br>Produced fluids is a concern | Regional resource<br><br>Reservoirs must be managed to avoid depletion<br><br>Technology developments in areas such as geothermal heat pumps hold promise | Competitive cost of electricity | Good source of baseload electricity | No unique public safety issues | No unique system security issues |
| Energy Efficiency | No atmospheric emissions<br><br>Carbon friendly technology | Energy intensity reductions have reduced energy costs by billions of dollars | Low cost for meeting energy needs<br><br>Best when energy costs are high | Reduces need for electricity | No unique public safety issues | No unique system security issues |

*Source:* CECA, 2006

# CHAPTER SEVEN:

# A Brief History of Energy and Environmental Policies in the United States 1901 - 2005

## 7.0 Introduction

The structure of the U.S. energy industry today has evolved over the past century, marked by technological innovations and domestic fuel use policy decisions. Energy policies being developed by Congress and the States today will set the course for future fuel use and investment decisions. This chapter attempts to outline briefly the history of the majority of energy and environmental decisions that have influenced fuel use in the United States since the time of the Industrial Revolution.

This chapter begins with a review of how fuel use technology provided the impetus for the nation to move from an agricultural society to an industrial/manufacturing society. The Federal government's management of Federal lands, the emergence of public power, and the roots of the nation's electric power industry had important impacts on fuel use. The progress from wartime uses of the atom to the beginnings of the nuclear power industry also "set the stage" for today's fuel use decisions.

The evolution of regulation of the energy industry is also briefly analyzed. The movement towards the command-and-control approach to energy regulation had obvious great influence on fuel choice. Yet, growing concern regarding the environmental impacts of fuel use, coupled with the emergence of the Environmental Movement of the 1970s, led to sweeping air, water and land use legislation which also dictated fuel utilization. National environmental protection criteria were established that changed the course of fuel use as never witnessed before. Environmental concerns also led to a new approach to regulation characterized by the introduction of cap-and-trade programs.

Following the nation's experience with market-based environmental regulation, a shift from regulated, rate-of-return, franchise monopoly utility structure to competitive wholesale markets was implemented. These trends and the political events that influenced the evolution of fuel use are summarized in this chapter.

The Consumer Energy Council of America recognizes that some significant policies have not been fully articulated and many details have been left out of this overview. However, the purpose of this chapter is to provide a background on the evolution of energy and environmental policies and how those policies have influenced the way the nation approaches fuel use and the subsequent consequences today. By reviewing the evolving approaches to energy policy, the reader will have a common basis of understanding of the history of energy policy and its impact on fuel use.

## 7.1 Fuel Use at the Beginning of Modern Society: America to 1900

Prior to the Industrial Revolution, America's economy was based almost exclusively on agriculture. Fuel use consisted primarily of non-fossil fuels and energy was derived from biomass, wind and water. The U.S. economy relied on biomass resources for much of its early development. During this time, fossil fuel use was beginning to be explored in other nations. England, for example, had been using coal since the Middle Ages. Over time, flooding from underground reservoirs had compromised many coal mines. In 1712, the advent of the atmospheric steam engine, developed by Thomas Newcomen, dramatically increased the efficiency of coal mining. Newcomen's machine used coal-energy to pump water out of mineshafts. This decreased the cost of coal and marked the beginnings of the widespread coal use that powered the Industrial Revolution.[1]

While coal was becoming a valuable commodity in England, foundations of modern hydropower generation were being developed in France. Technical innovations in the mid-1700s concerning the use of the vertical-axis turbine formed the basis for the modern hydropower turbine and allowed for

1 Wade Fraiser, "The Energy Racket: The Industrial Revolution and the Science of Energy," at http://www.ahealedplanet.net/energy.htm#industrial, accessed on June 16, 2005.

the efficient utilization of the kinetic energy found within many waterways around the world.[2]

In the U.S., the Industrial Revolution signaled a conversion from an agricultural economy to a manufacturing economy. This shift was largely driven by increased coal production that had been made possible by the Newcomen engine. Coal was first produced in the U.S. in 1748.[3] Prior to this time, most coal used in America was imported from England, which had well developed reserves. In 1769, James Watt separated the cooling process from the main cylinder of the Newcomen engine and improved the engine's efficiency by 75 percent. These improvements dramatically reduced the amount of coal needed to operate the steam engine. On both sides of the Atlantic this resulted in increased production and helped to fundamentally change the way societies used energy.

The economic boom of the Industrial Revolution led to the development of other fuel sources as well. In 1816, the Baltimore Gas & Electric Company, the nation's first utility, was supplying gas that was manufactured from coal to power the street lamps of Baltimore, Maryland.[4] William Hart dug the first successful American natural gas well in 1821 in Fredonia, New York. The Fredonia Gas Light Company opened its doors in 1858 and became the nation's first natural gas company.[5]

The world's first working oil well was drilled in Titusville, Pennsylvania in 1859 and the first oil refinery followed soon after in 1862. Robert Bunsen invented the Bunsen burner in 1885, which used natural gas and air to maintain a flame that could be used for heating and cooking. The theoretical beginnings of modern nuclear power began in 1904 when British physicist Ernest Rutherford developed the theory that the controlled fission of heavy elements could release enormous amounts of energy.[6]

Thomas Edison's Pearl Street electricity generating station opened on September 4, 1882 in New York City. Electric generation facilities had been constructed previously, but Edison's coal-fired plant introduced the four key elements of a modern electric utility system: reliable central generation, efficient distribution, a successful end use (the light bulb), and a competitive price. The system that he designed used one-third the amount of fuel of its predecessors.[7]

The first hydropowered electric street lamps in the U.S., which used arc and incandescent lighting, were installed in Niagara Falls in 1881.[8] The first U.S. hydroelectric plant was built in 1882 in Appleton, Wisconsin.[9] Shortly afterwards, in 1896, the Niagara Falls hydroelectric plant was inaugurated, overcoming previous shortfalls in transmission technology, providing power to remote locations up to twenty miles away from the generation site.[10]

## 7.2 Beginning of the Electric Power Industry: 1901 to 1932

### Hydropower on Federal Lands

The economic prosperity expected to result from the newly developed hydropower industry led Congress to pass the Federal Water Powers Act in 1901. This Act gave the Secretary of the Interior the authority to issue licenses for water rights on Federal lands. The Federal government, which owns the majority of the nation's hydroelectric resources, could now provide licenses to a private party without bequeathing land rights. This allowed for private construction of hydroelectric facilities on Federal land and signaled the beginning of the Federal government's involvement in the energy industry. The following year, in 1902, the Bureau of Reclamation was established and immediately became involved in hydropower production in conjunction with water resource management activities in the West.[11]

### Regulation of the Emerging Electric Power Industry

After 1901, growing steam engine efficiency and the shift from wood to steel natural gas pipelines, in the 1860s, allowed for increased electric generation.[12] Smaller companies had economic incentives to merge and form more efficient private multi-service systems that could include small lighting, railroad and power companies.[13] Competition between these firms led to confusing and inefficient transmission structure

2 Department of Energy, "History of Hydropower," at http://www.eere.energy.gov/windandhydro/hydro_history.html, accessed on June 20, 2005.
3 Kentucky Coal Education, "History of Coal," at http://www.coaleducation.org/Ky_Coal_Facts/history_of_coal.htm, accessed on June 18, 2005.
4 Baltimore Gas & Electric Company, "History," at http://www.bge.com/portal/site/bge/menuitem.dcdb00ae9edeb438ec8f1457025166a0/, accessed on June 20, 2005.
5 Connecticut Natural Gas Corporation, "Origins of Natural Gas," at http://www.cngcorp.com/community_center/origin_of_natural_gas.html, accessed June 20, 2005.
6 U.S. Department of Energy, "The History of Nuclear Energy," Office of Nuclear Energy, Science & Technology, DOE/NE-0088 at http://www.nuc.umr.edu/nuclear_facts/history/history.html, accessed July 5, 2005.
7 Energy Information Administration "Appendix A: History of the U.S. Electric Power Industry, 1882-1991," In The Changing Structure of the Electric Power Industry: An Update, 1996.
8 United States Bureau of Reclamation, "History of Hydropower Development in the United States," at: http://www.usbr.gov/power/edu/history.html, accessed June 22, 2005.
9 *Ibid.*
10 Energy Information Administration, "Appendix A."
11 United States Bureau of Reclamation, "History of Hydropower Development in the United States."
12 Pipeline 101, "History of Pipelines," at http://www.pipeline101.com/History/index.html, accessed June 25, 2005.
13 Energy Information Administration, "Appendix A."

and services.[14] Early regulation was implemented on local levels, promoting the benefits of the natural monopoly structure. This early regulation did not serve to eliminate corruption in the industry and it became apparent that more cohesive regulation was needed.[15] Samuel Insull, President of the National Electric Light Association (NELA),[16] delivered an address to NELA in 1898 in which he proposed State regulation of utilities in return for fixed rates and long-term natural monopoly franchises.[17] In the early 1900s consumer frustration with high prices and unreliable service, and extensive industry lobbying encouraged State legislatures to pass legislation that provided for State utility regulation.

In 1907, Public Utility Commissions (PUCs) were created in Wisconsin, Georgia, and New York to implement State-level regulations.[18] Other States quickly followed this example and developed their own PUCs, which reviewed utility expenses and established rates for various classes of customers that reflected expenses, depreciation on equipment and materials, and the cost of capital needed for consistent future generation. State PUCs obligated utilities to serve all customers within their State-defined service areas under these regulated prices as well as establish utility accounting systems.[19]

As vertically integrated electric power companies continued to gain market power and the advent of electric appliances pushed up consumer electricity needs, the government looked for ways to ensure that generation continued to meet growing demands. The Federal Power Act of 1920 established the Federal Power Commission (FPC) to coordinate hydroelectric projects under Federal control and provided for cooperation between the FPC and other Federal agencies in the licensing of power projects.[20] For the next several years, the FPC struggled to produce a coherent, consistent energy policy.[21]

Following the advent of State utility regulation, some enterprising investors, such as Insull, established large complex private holding companies that controlled franchises in multiple States. Because States lacked the authority to regulate interstate commerce, these firms were able to control large networks of utility operations and exert significant market power. In the late 1920s, the 16 largest electric power holding companies controlled more than 75 percent of all U.S. privately held generation capacity.[22]

## 7.3 Federal Regulation of the Electric Power Industry: 1933 to 1944

On October 24, 1929, the Great Depression began with Black Thursday when the Dow Jones Industrial Average dropped 50 percent. The Great Depression led to massive bank failures, a high unemployment rate, and dramatic drops in GDP, industrial production, and stock market share prices. In January 1931, President Franklin D. Roosevelt was sworn into office and immediately proposed that Congress enact a sweeping program – known as the "New Deal" – designed to bring economic recovery.

### Federal Government Investment in Hydropower

On May 18, 1933, as part of his New Deal agenda, President Roosevelt signed the Tennessee Valley Authority Act into law.[23] The Tennessee Valley Authority (TVA) was designed to improve navigability on the Tennessee River, produce electric power for the Tennessee Valley, provide for flood control, plan for reforestation and the improvement of marginal farm lands, assist in industrial and agricultural development, and aid the national defense in the creation of government nitrate and phosphorus manufacturing facilities.[24] The TVA is still the largest Federal power producer and markets its power in both retail and wholesale markets.[25]

The Bonneville Project Act of 1937 was passed just prior to the completion of the Bonneville and Grand Coulee dams in 1938 and 1941.[26] The Act was passed in anticipation of the need to market power generated from these two dams. Congress addressed the growing concern about recent market power practices in the electric power industry with the creation of the Bonneville Power Administration (BPA). The BPA was charged with marketing wholesale electricity and transmission to States, counties, municipalities and nonprofit cooperatives.[27] One of BPA's early missions focused on providing electricity to farms and small communities in the region.[28] The BPA's mandate served to electrify many rural areas that had previously been without power and relied on the vast hydropower resources in the region.

14 Consumer Energy Council of America, *Positioning the Consumer for the Future: A Roadmap to an Optimal Electric Power System*. April 2003.
15 *Ibid*.
16 Patrick McGuire and Mark Granovetter. "Business and Bias in Public Policy Formation: The National Civic Federation and Social Construction of Electricity Regulation, 1905-1907," August 1998.
17 *Ibid*.
18 Consumer Energy Council of America, *Positioning the Consumer for the Future: A Roadmap to an Optimal Electric Power System,* April 2005.
19 Energy Information Administration "Appendix A."
20 United States Fish and Wildlife Service, *Digest of Federal Resource Laws of Interest to the U.S. Fish and Wildlife Service*.
21 Federal Energy Regulatory Commission, "What is FERC: History," at http://www.ferc.gov/students/whatisferc/history.htm, accessed June 20, 2005.
22 Energy Information Administration "Appendix A."
23 48 Stat. 58-59, 16 U.S.C. sec. 831.
24 New Deal Network, "TVA: Electricity for All," at http://newdeal.feri.org/tva/tva01.htm, accessed June 25, 2005.
25 Energy Information Administration "Appendix A."
26 Bonneville Power Administration, "About BPA," at http://www.bpa.gov/corporate/About_BPA/, accessed July 7, 2005.
27 Energy Information Administration "Appendix A."
28 Bonneville Power Administration, "About BPA."

## Federal Regulation of Electric Systems

The devastating financial effects of the Great Depression helped to expose the scandalous business practices of many private holding companies, which were forced into bankruptcy in the early 1930s. This led to widespread concern about the interstate electric power industry, its influence, and the integrity of electric systems. To counter utility abuses beyond State control, Congress passed the Public Utility Holding Company Act of 1935 (PUHCA), which provided for the regulation of interstate transmission.[29] The Federal Power Act of 1935 (Title II of PUHCA) established FPC regulation of utilities involved in interstate wholesale transmission and electric power sales.[30]

At the time, the structure of the utility industry made it economically unattractive to develop electricity services in rural areas. In the mid 1930s, many consumers in rural areas were still without electricity. The cost of building transmission lines from central generating stations to rural areas made it uneconomical for investor-owned utilities to serve rural America. To encourage the growth of rural electricity service, the Federal government enacted legislation to subsidize the formation of rural electric cooperatives through the Rural Electrification Act of 1936 (REA).[31] As a result of the REA, rural electric cooperatives were formed throughout the U.S. to serve rural America.[32] To this day, rural electric cooperatives purchase power from other utilities as well as provide generation and transmission services.

Electric generating systems continued to grow in size and efficiency through the 1940s and corresponding improvements were introduced in transmission and distribution systems.[33] The Southwestern Power Administration and the Southeastern Power Administration were established in 1943 and 1950, respectively, contributing to total Federal generation, which grew to 12 percent of U.S. generation by the end of World War II.[34]

## Federal Regulation of Natural Gas

Natural gas companies had been subject to the same local and State regulations as electric utilities and had developed the same natural monopoly structure. When pipeline technology allowed for the interstate sale and transport of natural gas, State regulations no longer sufficed. In addition, non-utility firms that engaged in the sale of natural gas were not regulated by PUCHA. Between 1911 and 1928, several States sued natural gas companies in Federal courts to assert regulatory oversight of these interstate pipelines. The U.S. Supreme Court ruled in favor of natural gas companies and held that such State oversight of interstate pipelines violated the Interstate Commerce Clause of the U.S. Constitution. These cases were known as the "Supreme Court Commerce Clause" cases.[35]

When State regulation of interstate commerce was deemed unconstitutional, the situation pointed to the need for Federal regulation. In 1935, a report prepared by the U.S. Department of Justice and the Federal Trade Commission raised concern about a growing trend towards monopolistic abuse of market power by interstate pipeline companies and prompted passage of the Natural Gas Act of 1938 (NGA).[36] The NGA was the first instance of direct Federal regulation of the natural gas industry. It gave the FPC the authority to set "just and reasonable rates" for the transmission or sale of natural gas in interstate commerce.[37]

## 7.4 The Development of Nuclear Power: 1953 to 1969

After World War II, policymakers felt that nuclear technology had potential for peaceful purposes and that to facilitate this potential, oversight should move out of the Defense Department. At the same time, however, policymakers also felt the need to keep control over this new technology and nuclear materials. The subsequent Atomic Energy Act of 1946 prohibited private or commercial development of nuclear power and established the Atomic Energy Commission (AEC), which provided for the appointment by the President—then Harry S. Truman—of five civilian commissioners to foster and control the peacetime development of atomic science and technology.[38] The Act also authorized a cooperative arrangement for constructing the first full-scale civilian nuclear power plant in the U.S. to determine the practicability of nuclear power for civilian purposes, which the AEC implemented on December 7, 1953.[39]

The AEC's regulatory programs sought to ensure public health and safety from the hazards of nuclear power without imposing excessive requirements that would inhibit the growth of the industry. The new Commission was designed

29 Public Utility Holding Company Act of 1935, P.L. 74-333.
30 Energy Information Association "Appendix A."
31 Basin Electric Power Cooperative, "History—Power for the People: 1930-1957," at http://www.basinelectric.com/Profile/Companies/History/, accessed July 7, 2005.
32 Alex Radin, Public Power—Private Life, American Public Power Association, Washington D.C., 2003.
33 *Ibid.*
34 Edison Electric Institute, *Historical Statistics of the Electric Utility Industry Through 1970*, New York, NY.

35 Natural Gas Supply Association, "Overview of Natural Gas," at http://www.naturalgas.org/overview/history.asp, accessed June 27, 2005.
36 Federal Energy Regulatory Commission, "Energy We Regulate: Natural Gas," at http://www.ferc.gov/students/energyweregulate/gas.htm, accessed June 27, 2005.
37 Energy Information Administration, "Natural Gas Act of 1938," at http://www.eia.doe.gov/oil_gas/natural_gas/analysis_publications/ngmajorleg/ngact1938.html accessed June 27, 2005.
38 Alice L. Buck, "A History of the Atomic Energy Commission," U.S. Department of Energy History Division. July, 1983.
39 Atomic Energy Commission, "History of the Cooperative Power Reactor Demonstration Program," Washington, DC. 1964.

to maintain a high level of independence and control. Commission employees were exempt from the Civil Service System in order to assure complete freedom in hiring scientists and professionals. Issues of national security mandated that all production facilities and nuclear reactors would be government-owned, and that all technical information would be under Commission control. The National Laboratory system was established from the facilities created under the Manhattan Project, and Argonne National Laboratory was one of the first laboratories authorized under this legislation as a contractor-operated facility dedicated to fulfilling the new Commission's mission.[40]

In the early 1950s, the U.S. became a net importer of crude oil and nuclear power was seen as a critical means of avoiding dependence on imported fuel.[41] This belief, in combination with further research concerning the capabilities of nuclear power by the Federal government, encouraged the drafting of legislation that allowed for private ownership and operation of reactors. The resulting Atomic Energy Act of 1954 (AEA) set the development of a regulated commercial nuclear power industry as an urgent national goal.[42]

While procedures for nuclear plant siting had been developed, private investors were unable to secure adequate insurance to guard against lawsuits that would inevitably follow should a reactor critically malfunction. Demand for energy was growing as the population surged after WWII. Births increased 3.6 percent in 1946 alone, and Congress was committed to finding ways to meet this growing demand. This led to the passage of the Price-Anderson Act of 1957, which reduced private liability for nuclear reactors by guaranteeing compensation in the event of a commercial nuclear accident. The first commercial nuclear reactor in the U.S. subsequently began operations in Shippingport, Pennsylvania in December of 1957.[43]

## 7.5 The Environmental Movement: 1970 to 1977

In 1962, Rachel Carson published *Silent Spring*, which meticulously described the dangers of modern pesticide use.[44] The book was a popular success and was credited with leading to the birth of the modern American Environmental Movement. The popularity of the book was due, in part, to the time of its release. In the 1960s, standards of living were beginning to improve, as post-war employment increased. The ideology of the time spawned many great American movements in addition to the Environmental Movement, including the Civil Rights Movement, the Peace Movement, and the Women's Movement.

On April 22, 1970, environmental advocates organized the first Earth Day, designed to challenge the environmental status quo through peaceful mass mobilization.[45] On that day, 20 million Americans came together in celebration of quality-of-life issues and concern for the environment. The enormous support for the environmental agenda did not go unnoticed. In fact, support grew so that over the next several years, Congress dramatically increased its enactment of environmental legislation.[46]

### The Environmental Protection Agency Is Established

In response to emerging environmental advocacy, the National Environmental Policy Act (NEPA) was signed into law on January 1, 1970, marking the real naissance of environmental regulation in the United States. NEPA established a national policy to protect the environment and required the preparation of Environmental Assessments (EA) and Environmental Impact Statements (EIS) for any major action significantly affecting the environment.[47] To further support growing environmental concerns, in July 1970 Congress, with the support of the White House, established the Environmental Protection Agency (EPA) to regulate air, water, noise, pesticides and hazardous wastes and subsequently forwarded the procedural mandates of NEPA to the new agency.[48]

### Air Quality Regulations Emerge

Many State and local governments had enacted legislation targeted at maintaining air quality standards prior to Federal air quality legislation. Air quality pollutants, from dust and smog to acid rain and ozone, proved to be difficult to control with State-level regulations. The nature of air and atmospheric processes, which function irrespective of State borders, also contributed to the inadequacy of State policies.

To establish a comprehensive national air quality management system, Congress passed the Clean Air Act of 1970 (CAA), which established National Ambient Air Quality Standards (NAAQS) that regulate six criteria pollutants: sulfur dioxide

40 Wikipedia – The Free Encyclopedia, "United States Atomic Energy Commission," at http://en.wikipedia.org/wiki/Atomic_Energy_Act, accessed June 22, 2005.
41 Department of Energy, "Energy in the United States 1635-2000: Nuclear," at http://www.eia.doe.gov/emeu/aer/eh/frame.html, accessed June 21, 2005.
42 U.S Nuclear Regulatory Commission, "Our History," August 11, 2004.
43 Department of Energy, "Uranium Stewardship Activities: History," at http://www.ne.doe.gov/uranium/history.html, accessed June 18, 2005.
44 Rachel Carson, *Silent Spring*. Mariner Books; Reprint edition, September, 1994.
45 Earth Day Network, "Information about Earth Day and Earth Day Network." at http://www.earthday.net/about/faq.aspx, accessed July 7, 2005.
46 Alvin L. Alm, "NEPA: Past, Present, and Future," Environmental Protection Agency Journal, January/February 1988.
47 *Ibid*.
48 Environmental Protection Agency, "Historical Timeline," athttp://www.epa.gov/history/timeline/70.htm, accessed April 18, 2005.

($SO_2$), nitrogen dioxide ($NO_2$), particulate matter (PM), carbon monoxide (CO), ozone ($O_3$), and lead (Pb) emissions. The CAA imposed statutory deadlines for compliance with NAAQS. These mandatory compliance dates were aimed at correcting the shortcomings of the previous air quality legislation.49 The Act also obligated States to develop State Implementation Plans (SIP) that outlined the actions they would take to meet the new standards.

The CAA also established the Prevention of Significant Deterioration Regulations (PSD). The CAA stipulates that in areas that have attained NAAQS, PSD provisions are applicable upon the submission of a permit application for a new stationary source with potential air emissions. The PSD program within the CAA was designed to preserve the attainment status in areas that had achieved the standards.

The EPA was also empowered to establish New Source Performance Standards (NSPS) as part of the CAA, which applied to all new plants, or major additions to existing plants, regardless of size or location. Since Congress was concerned about creating unfair advantages for specific regions of the country where new industrial growth was attractive, (i.e., plants would locate where the NAAQS requirements were less restrictive), they directed that the NSPS requirements applied to all new major sources, regardless of an area's attainment designation. The Act required States to develop regulatory infrastructure that accomplished the NSPS.[50]

The 1970 CAA also established New Source Review (NSR) requirements, which limit the emissions of all new point sources[51] to a fixed rate. However, the NSR statutory requirements resulted in a significant discrepancy between the allowable amount of emissions new generating facilities were permitted to produce and the allowable emissions from facilities built before 1970. The NRS program was designed to reduce overall emissions through normal plant attrition as newer, more efficient plants replaced existing facilities. However, the unintended result was the ability of many existing generation facilities to meet the criteria to be "grandfathered" from the new stringent NSR requirements. The ability to be grandfathered created a powerful financial incentive for owners to keep those facilities in the marketplace and many plants continued to operate far longer than expected.[52]

Emissions reduction regulations mandated under the CAA gave an advantage to coal producers in Western States. Coal found in these deposits tends to be low in sulfur and when low sulfur coal is burned, fewer pollutants are emitted than when an equal amount of high sulfur coal is used. Because the CAA measured all emissions that came out of the stack regardless of the amount of fuel used, many plants switched to burning Western, low sulfur coal. This was typically a more cost-effective strategy than installing costly plant improvements.

In 1977, pressure from Eastern coal interests helped lead to amendments to the CAA. The 1977 Amendments included a "percent reduction" formula, which required the removal of a percentage of potential $SO_2$ emissions, determined by the sulfur content of the fuel. This policy shifted the focus of the Act away from air quality standards toward increased regulation of stationary sources of pollution and required all new coal plants to remove sulfur from their exhaust through flue-gas desulfurization, or "scrubbing." The new regulation eliminated the incentive to use low-sulfur fuel as a cost efficient alternative to scrubbers.53

The programs instituted under the CAA in the 1970s consisted of command-and-control policies. Command-and-control policies rely on regulation, including permits, standard setting and enforcement, as opposed to economic instruments of cost internalization. No incentives were provided for attainment of standards, other than the avoidance of fines or actions that would be imposed in the case of non-compliance. Firms had no way to benefit from these regulations and viewed command-and-control policies as additional costs of production, which were then passed on to consumers. Much of the early environmental legislation in the U.S. consisted of similar command-and-control policies. Pertinent examples of this include policies enacted to monitor the water contaminated by stationary fuel use applications and ensure that water quality standards were met.

## Water Quality Regulation Impacts Fuel Use

The Federal Water Pollution Control Act of 1972 (FWCPA) constituted a comprehensive reworking of various piecemeal legislation pertaining to water quality. Most importantly, from the perspective of stationary source applications, the 1972 Act changed the thrust of enforcement from water quality standards, which regulated the amount of pollutants in a given body of water, to effluent limitations, which regulated pollutants that were discharged from

49 Paul G. Rogers, "The Clean Air Act of 1970," *Environmental Protection Agency Journal*, January/February 1990.

50 American Meteorological Society, "Stationary Sources; Emissions from Factories and Industry." at http://www.ametsoc.org/sloan/cleanair/, accessed June 18, 2005.

51 Point sources of pollution occur when harmful substances are emitted directly into a body of water from readily identifiable inputs where waste is discharged to the receiving waters from a pipe or drain.

52 National Academy of Public Administration, *A Breath of Fresh Air: Reviving the New Source Review Program, Summary Report*, April 2003.

53 It should be noted that like any generalization, not all Eastern coal was high sulfur, nor was all Western coal low sulfur, however, the debate was framed as such. In retrospect, the regional aspect of the debate was unnecessary as Western coal's share of national production, particularly from the Powder River Basin, has steadily increased as a result of the continuing focus on sulfur emissions.

particular point sources.[54] The National Pollution Discharge Elimination System (NPDES) was introduced in this Act and, according to the EPA, has subsequently been responsible for significant improvements in water quality.[55] NPDES is a permit program that regulates point source polluters. Permits are required of facilities that discharge directly into surface waters. The permit provides both technology-based limits, based on the ability of similar facilities to treat wastewater, and water quality-based limits, which go into effect if technology-based limits are insufficient to protect the body of water. States have the option of organizing a permit program as long as the EPA authorizes it.[56]

FWPCA requires that the States submit water quality standards to the EPA for all interstate and intrastate navigable waters as well as establish maximum daily loads of all permitted pollutants. Standards are set at a level that allows for the propagation of fish and wildlife. Of particular importance to industrial facilities is the inclusion of a regulation requiring assessment for thermal discharges. The FWCPA was amended in 1977 to become the Clean Water Act (CWA).[57] In section 316(b) of the CWA, cooling water intake structures were addressed, affecting more than 1,500 industrial plants, which use enormous amounts of water from lakes, rivers, estuaries, and oceans to cool their facilities. Such plants include steam electric power plants, pulp and paper manufacturers, chemical manufacturing plants, petroleum refining plants, and primary metal manufacturing plants.[58]

## Nuclear Power Emerges as a Clean Alternative

Growing attention to environmental issues and increased regulation of stationary power sources contributed to the search for cleaner fuels. Utilities viewed nuclear power as an economic, safe, and environmentally responsible technology. By 1970, nuclear power had increased to over one percent of the nation's electric generation.[59] From 1971 to 1974, 131 new nuclear units were ordered. However, inflation and increases in real labor and materials costs led to rising construction expenses. At the same time, high interest rates raised financing costs of new nuclear plants. Capital costs rose from about $150 per kilowatt in 1971 to over $600 after 1976.[60]

Rising costs led some critics to charge that the Atomic Energy Commission's regulations were excessively rigorous in several important areas, including radiation protection standards, reactor safety, plant siting, and environmental protection.[61] With the passage of the Energy Reorganization Act of 1974, the AEC was replaced by the Nuclear Regulatory Commission (NRC), which focused its attention on issues involving civilian use of nuclear power,[62] and the Energy Research and Development Administration, which managed nuclear weapons, naval reactors, and energy development programs.[63] The NRC was charged with re-examining regulatory procedures for the nuclear power industry, such as the permitting procedure managed by the AEC. This was a two-step process: a permit was required prior to construction of a new nuclear facility and a second permit was required after construction but prior to operation.[64]

Nuclear power continued to be seen as a positive and environmentally friendly power option. However, disposal of nuclear waste became a contentious issue as nuclear reactors began to produce greater amounts of spent fuel. In 1977, President Jimmy Carter announced that the United States would indefinitely defer plans for reprocessing spent nuclear fuel. Reprocessing of spent nuclear fuel reduces overall waste by reusing the fuel, however, separated fissile materials produced after reprocessing are highly reactive and can be used in the construction of nuclear weapons. President Carter was dedicated to the idea of nuclear non-proliferation and the nation supported this concept. His decision in 1977 was centered on multi-national concerns over potential proliferation of weapons-grade nuclear materials. Despite the advantages of a reduced amount of spent nuclear fuel, as well as the later nullification of this moratorium by President Ronald Reagan,[65] the U.S. never began to commercially reprocess spent fuel.

54 Michael R. Lozeau Esq., "Testimony Before The Senate Environment And Public Works Subcommittee On Fisheries, Wildlife, And Water," *Earth Justice*, September 16, 2003.
55 Environmental Protection Agency, "National Pollution Discharge Elimination System," at http://cfpub.epa.gov/npdes/, accessed June 22, 2005.
56 *Ibid*.
57 Senator Edmund S. Muskie, "The Meaning of the 1977 Clean Water Act," EPA Journal, July-August, 1978.
58 Environmental Protection Agency, "Industrial Water Pollution Controls," at http://www.epa.gov/waterscience/pollcontrol, accessed July 7, 2005.
59 Energy Information Administration, Annual Energy Review, 1984.
60 Energy Information Administration, "1983 Survey of Nuclear Power Plant Construction Costs," DOE/EIA-0439(84) Washington, DC, December 1983.
61 United States Nuclear Regulatory Commission, "Our History."
62 *Ibid*.
63 Department of Energy Office of History and Heritage Resources, "Department of Energy History: An Overview," at http://ma.mbe.doe.gov/me70/history/overview.htm, accessed June 18, 2005.
64 United States Nuclear Regulatory Commission, "A Short History of Nuclear Regulation, 1946-1999," at http://www.nrc.gov/who-we-are/short-history.html, accessed July 7, 2005.
65 Nuclear Management Company, "About Nuclear Waste Disposal," at http://www.nmcco.com/education/facts/waste/waste_home.htm, accessed July 7, 2005.

## 7.6 Federal Agency Developments and Comprehensive Legislation: 1975 to 1978

### Federal Land Management Impacts on Fuel Use

In the late 1970s, a series of land use legislative initiatives resulted in a number of specialized Federal agencies having regulatory authority over stationary sources. The Federal Land Policy and Management Act of 1976 (FLPMA) authorized the Bureau of Land Management (BLM) within the Department of the Interior (DOI) to manage the Federal domain for multiple uses. FLPMA specifies that the BLM must utilize a land use planning process that is based on sustainable yields[66] and allows for multiple uses. These include the exploration and development of energy fuels. According to the BLM's multiple use directive, a balance must be reached between different uses of Federal lands such as power generation, recreation and wildlife preservation initiatives.

The Surface Mining Control and Reclamation Act of 1977, which created the Office of Surface Mining Reclamation and Enforcement (OSM) within the DOI,[67] also affected stationary power. The OSM is responsible for regulating active coal mines through a permitting process to ensure that operations are safe and environmentally sound. The Abandoned Mines Program of the OSM was designed to remedy problems resulting from past mine use, such as environmental degradation. This program is funded through an excise tax on coal production, thus affecting the price of coal-generated electricity.[68]

### The U.S. Department of Energy Is Established

The nation's energy requirements were continuing to grow more complex with the emergence of new technologies, sophisticated environmental advocacy, and the continued reliance on imported oil from the Middle East. The growing energy crisis, which stemmed from disruptions in fuel supply caused by the Arab oil embargo in 1973, made it evident to policymakers that a unified national energy strategy was needed. In 1977, the Department of Energy Organization Act was passed to consolidate the Federal government's energy agencies and programs into the U.S. Department of Energy. The DOE assumed the responsibilities of the Federal Energy Administration,[69] the Energy Research and Development Administration, as well as the energy-related functions of the Department of the Interior, specified functions of the Secretary of Housing and Urban Development, the Interstate Commerce Commission, the Secretary of the Navy and the Secretary of Commerce. The DOE manages high-risk research and development of energy technology, Federal power marketing agencies, energy conservation, the nuclear weapons program, energy regulatory programs, and a central energy data collection and analysis program.[70] The Department of Energy Organization Act also created the Federal Energy Regulatory Commission, which is composed of five members appointed by the President and confirmed by the Senate.[71] The Act transferred the regulatory functions of the FPC to this new Commission.[72]

### The National Energy Act of 1978 Guides Fuel Choice

Federal regulations governing the electric power industry remained fairly unchanged from the passage of PUHCA until the late 1970s. The most prominent events leading to the passage of the National Energy Act (NEA) of 1978 were the Arab oil-producing nations' ban on oil exports to the U.S. in 1973 and the political unrest that shook Iran in 1978.[73] Congress wanted to ensure against further dependence on oil and passed the NEA in response to the impacts of the Arab oil embargo on the nation's economy and the increased anxiety over the safety and security of its energy supply.[74] The NEA included five different statutes: the Public Utility Regulatory Policies Act (PURPA), the Energy Tax Act, the National Energy Conservation Policy Act (NECPA), the Natural Gas Policy Act (NGPA), and the Power Plant and Industrial Fuel Use Act (FUA).[75] All five of these new energy statutes had tremendous influence on energy policy in the years to come.

#### Public Utility Regulatory Policies Act

FERC had taken over the regulatory functions of the FPC in January 1978, the year that PURPA was passed by Congress as part of the NEA, and FERC was therefore responsible

66 The amount of a naturally self-reproducing community (i.e., fisheries) that can be harvested without diminishing the ability of the community to sustain itself.
67 Indiana Division of Reclamation, "History," at http://www.in.gov/dnr/reclamation/DOR/History.html, accessed June 23, 2005.
68 Department of Energy, "Office of Surface Mining Reclamation and Enforcement," at http://www.doi.gov/pfm/ar4osm.html, accessed June 22, 2005.
69 The Federal Energy Administration had been established in 1974, under the Energy Reorganization Act of 1974, to take over the responsibilities of the Federal Energy Office. The Federal Energy Office was established in December 1973 to replace the Energy Policy Office, which had been created earlier that year.
70 Department of Energy Office of History and Heritage Resources, "Department of Energy History: An Overview."
71 Library of Congress; THOMAS – U.S. Congress on the Internet, "Bill Summary & Status for the 95th Congress – S.826 Public Law: 95-91 (8/4/77)."
72 *Ibid.*
73 Energy Information Administration "Appendix A."
74 Amy Abel, Electricity Restructuring Background: The Public Utility Regulatory Policies Act of 1978 and the Energy Policy Act of 1992, CRS Report for Congress #98-419, May 4, 1998.
75 Kanner & Associates "Legislative and Regulatory Affairs, Federal Energy Law Summaries," at http://www.kannerandassoc.com/energy%20laws.html, accessed June 20, 2005.

for the implementation of PURPA. PURPA was intended to promote the development of renewable energy sources and required regulated utilities to purchase a percentage of their total power from independent power producers, rather than producing all their own power. A class of independent power producers was defined in PURPA as "qualifying facilities" (QFs). QFs were exempt from regulation under PUHCA and the Federal Power Act. Two types of facilities qualified to be certified with FERC as QFs: small power producers and co-generators. Regulated utilities were mandated to purchase as much power as QFs were able to provide at or below the utility's avoided cost of generation. Provisions in the policy also decreased overall administrative costs of power sales by simplifying contracts, decreasing financial risks for creditors and equity sponsors, and eliminating barriers prohibiting smaller energy producers from entering into the market. These provisions were intended to increase the efficiency of electricity generation, promote renewable generation, as well as provide more equitable rates to electric consumers. Though it was not the original intent of Congress to spur wholesale electric market restructuring, the net result of the PURPA mandate was the beginning of wholesale electric utility competition. The policy encouraged independent power producers to invest in new, clean electric generation technologies such as combined-cycle cogeneration (combined heat and electric plants) and renewable fuels which could compete with the existing power plants and shifted the investment risk from ratepayers to the shareholders of QF facilities, These investments and shifts in market risks resulted in the weakening of market barriers, thus allowing QFs to compete with large utilities for new sources of needed generation from a variety of fuel source options.

## National Energy Conservation Policy Act

The Federal government took important steps towards energy conservation, an often-overlooked tool in the provision of energy services, with the NECPA. This Act mandated the establishment of procedures for the submission, approval, and implementation of residential energy conservation plans by State utility regulatory authorities and prescribed energy conservation measures to be included. Additionally, the Act established criteria to govern conservation programs for public utilities.[76] The NECPA was an attempt to address concerns about energy security, through the promotion of energy conservation, following the Arab oil embargo.[77]

## Natural Gas Policy Act

The Natural Gas Act, the predecessor to the Natural Gas Policy Act, gave individual States responsibility for pricing pertaining to the sale of natural gas to pipelines by producers. This led to the creation of pricing schedules, which protected producer States' interests at the expense of consuming States. These pricing schedules collapsed under the 1954 Supreme Court decision of *Phillips Petroleum Co. vs. Wisconsin Public Service Commission*, when regulatory jurisdiction was given to the NGA over the "sale for resale of natural gas by producers."[78] The NGA priced gas at the wellhead based on factors such as their age. This pricing policy caused natural gas prices to remain fairly low, as the factors influencing production, including the costs of finding, developing, and producing natural gas, were externalized and not reflected in the delivered price. These low prices coupled with the Arab oil embargo of 1973 led to a surge in natural gas demand.[79]

Not only did demand for natural gas surge in the 1970s, but supply shortages were experienced in consuming States. Despite increased demand, shortages existed due to an absence of intrastate pricing – only interstate pricing and producers could get higher bids from intrastate consumers.[80] In 1975, almost half of the nation's natural gas reserves went to intrastate consumers. The nation's interstate customers experienced increased supply shortages of natural gas during this period, and from 1976-77, many Midwestern schools and factories had to shut down due to the lack of natural gas to run their utilities. Attempts to fix this loophole constituted "curtailment" policies, which gave different priority status to intrastate consumers, taking supply away from those consumers deemed "low priority." Curtailment policies resulted in many litigation suits and helped lead to the enactment of the NGPA.

When policymakers included the Natural Gas Policy Act in the NEA, it was based on continued fear of potential natural gas shortages, price instability, and distorted supply policies. Policymakers believed that deregulation of wholesale gas markets would be the best means of keeping prices down for consumers and correcting the unintended consequences of the NGA. This concern culminated in the NGPA, which granted FERC authority over intrastate and interstate natural gas production and established wellhead price ceilings, some of which were to be subsequently phased out over time.[81]

76 Library of Congress; THOMAS – U.S. Congress on the Internet, "Bill Summary & Status for the 95th Congress – S.2057 Public Law: 95-91 (9/13/77)."

77 U.S. House of Representatives, "Energy Conservation Reauthorization Act of 1998," 105th Congress, Committee Report, at http://thomas.loc.gov/cgi-bin/cpquery/T?&report=hr727&dbname=cp105&, accessed July 12, 2005.

78 Baker Communications Inc., "Emerging Regulation of Exploration and Production (E&P)," at http://www.bakercommunications.com/whbt/section1d.htm, accessed June 22, 2005.

79 *Ibid*.

80 Natural Gas Supply Association, "History of Regulation," at http://www.naturalgas.org/regulation/history.asp, accessed June 22, 2005.

81 Energy Information Administration, "Natural Gas Policy Act of 1978," at http://www.eia.doe.gov/oil_gas/natural_gas/analysis_publications/ngmajorleg/ngact1978.html, accessed May 3, 2005.

The NGPA created new price schedules, which gave producers large incentives to find, develop, and produce natural gas.[82] The NGPA had three goals: (1) to create a single national natural gas market, (2) to make supply equal to demand, and (3) to allow market forces to set the wellhead price of natural gas.[83] The NGPA helped to move the natural gas industry towards deregulation by removing ceilings from the price of wellhead natural gas.[84]

### Powerplant and Industrial Fuel Use Act

In 1978, because of severe natural gas supply shortages, particularly during the 1976-77 winter, and projected sustained domestic gas supply shortages, Congress passed the Powerplant and Industrial Fuel Use Act (FUA) as part of the NEA.[85] The FUA prohibited utilities from using natural gas as a fuel for new electric generation and assured that the predicted limited supply of natural gas was available to provide consumers with heating and feedstock needs.[86] The implementation of the FUA resulted in significantly dampening gas demand. But, it also gave QFs, which were exempt from the Fuel Use Act, the ability to utilize low cost natural gas supplies in the new generation facilities they were building. The net result of the FUA was that QFs were able to supply lower cost natural gas-fired power, which the utilities were forced to purchase. This allowed QFs to increase their market share and function in some regions as an alternative natural gas supplier for wholesale electricity.[87] However, the FUA resulted in having many utilities in natural gas-rich regions to build coal-fired or nuclear facilities. It became clear by 1987 that the expected shortages of natural gas did not materialize, that there were negative unintended market consequences of the FUA, and Congress repealed the FUA.[88] However, the positive impacts to consumer prices of wholesale electric power competition had been realized through PURPA and FUA, even though neither statute was originally intended to result in wholesale electric power restructuring. Yet, as a result of these two statutes, policymakers began to consider energy policy that promoted wholesale competition in the electric power industry.

## 7.7 International and Domestic Events Influence Fuels Policy: 1979 to 1989

### Arab Oil Embargo

The Arab oil embargo directly affected oil prices in the U.S. in the mid 1970s. In 1975 in response to the oil embargo, Congress passed the Energy Policy Conservation Act which established the U.S. Strategic Petroleum Reserve (SPR). The SPR is the largest stockpile of government-owned emergency crude oil in the world. The SPR serves as an oil supply option should a disruption result from an interruption in the supply of imported petroleum products or domestic petroleum products and other emergencies that affect U.S. oil supply.[89] It also allows the United States to meet part of its International Energy Agency obligation to maintain emergency oil stocks, and it is an essential component of national defense planning.[90] Various kinds of fuel oils are obtained by distilling crude oil as discussed in detail in Chapter Six. In addition to transportation uses, fuel oil of differing varieties is used for home heating oil, and manufacturing processes for steam boilers and power generators. So, the availability of crude oil in the U.S. is extremely important for stationary source applications.

Upon his election, President Jimmy Carter sought to address oil shortages through heavy industry investment in oil shale development. In 1977, President Carter proposed the creation of an Energy Mobilization Board, through the National Energy Mobilization Act, that would fast-track the permitting process of new domestic energy projects and preempt local land use regulations and permitting procedures.[91] Congress, however, did not pass this legislation, responding to strong objections from environmentalists and local and State governments.[92]

Domestic oil and petroleum prices were deregulated in the 1980s. Before price deregulation, the market for domestic oil and gas derivatives was limited.[93] Price controls, which served to stabilize price, also resulted in shortages in some areas and surplus elsewhere and by complex cross-subsidies with accompanying efficiency costs.[94] Today the prices of crude oil and all petroleum products are free from Federal regulation

82 Baker Communications Inc., "Emerging Regulation of Exploration and Production (E&P)."
83 Natural Gas Supply Association, "History of Regulation."
84 *Ibid.*
85 Joseph P. Riva, "U.S. Conventional Wisdom and Natural Gas," at http://www.greatchange.org/bb-electricity-riva_on_ng.html, accessed July 12, 2005.
86 Julian Darley, High Noon for Natural Gas, White River Junction, VT: Chelsea Green Publishing Company, 2004.
87 Energy Information Administration, *The Changing Structure of the Electric Power Industry: An Update*, December 1996.
88 Energy Information Administration, "*Energy Policy Act Transportation Study: Interim Report on Natural Gas Flows and Rates, October 1995.*
89 DOE Office of Fossil Energy, "Petroleum Reserves," at http://www.fe.doe.gov/programs/reserves/index.html, accessed July 12, 2005.
90 *Ibid.*
91 Russell George, "Testimony for the Senate Committee on Energy and Natural Resources." Executive Director, Colorado Department of Natural Resources. April 12, 2005.
92 Jim Evans, "Testimony for the Senate Committee on Energy and Natural Resources." Executive Director, Associated Governments of Northwest Colorado. April 12, 2005.
93 Energy Information Administration, *Derivatives and Risk Management in the Petroleum, Natural Gas, and Electricity Industries*, October 2002.
94 J. Kalts, *The Economics and Politics of Oil Price Regulation*, Cambridge, MA: MIT Press, 1981.

## Natural Gas Deregulation

Moving toward complete wholesale deregulation took some time in the natural gas industry. Pipelines purchased natural gas from producers and sold it to local distribution companies (LDCs) at a regulated price under the NGA and NGPA.[95] The product was bundled, meaning that pipeline companies couldn't buy the natural gas and transportation services separately. Wholesale natural gas deregulation saw the "unbundling" of these products and services by means of Special Marketing Programs (SMPs) in the early 1980s. FERC permitted industrial customers to switch fuels, to purchase gas from the producers directly, and to use the pipelines strictly for transport. However, in 1985, SMPs were found to be discriminatory against "captive" customers by the D.C. Circuit Court and were retracted.[96]

The idea of customers purchasing their own natural gas and using pipelines as transporters rather than merchants was not abandoned with the abolition of SMPs.[97] The concept was kept alive with the implementation of FERC's Order No. 436, which gave all customers the rights that industrial fuel-switching companies had under SMPs, thus avoiding discrimination. Allowing customers to purchase their own natural gas and transportation arrangements became known as "open access."[98]

It was not until 1989 that wellhead pricing underwent complete deregulation under the Natural Gas Wellhead Decontrol Act of 1989 (NGWDA).[99] Under the NGWDA, the NGPA was amended and its remaining regulated prices were abolished, and pricing was left to the marketplace. Market pricing only pertained to "first sales" of natural gas, meaning to a pipeline, a distribution company, an end-user, any purchases preceding the sale to any of the above, or determined by the FERC to be a "first sale."[100] In 1993, FERC Order No. 636 decoupled the various components of the natural gas industry between wellhead and end-users. Order 636 was combined with FERC Order No. 637 which allowed pipeline companies to create a market determined by how their capacity would be used.[101] Significant restructuring has since affected the interstate natural gas pipeline industry and encouraged unbundled services, energy sector diversification and massive pipeline systems.[102]

95 Natural Gas Supply Association, "History of Regulation."
96 Municipal Gas Authority of Georgia, " Glossary of Terms," at http://www.gasauthority.com, accessed July 8, 2005.
97 *Ibid.*
98 *Ibid.*
99 Baker Communications Inc., "Emerging Regulation of Exploration and Production (E&P)."
100 *Ibid.*
101 Julian Darley, *High Noon for Natural Gas*.
102 Energy Information Administration, "United States Country Analysis Brief," January 2005.

## Nuclear Energy Events

In February 1979, the Nuclear Regulatory Commission shut down five operating nuclear reactors following concerns over durability in the event of an earthquake. Then, on March 28, 1979, the most significant commercial nuclear accident in the nation's history occurred at the Three Mile Island Number 2 reactor near Harrisburg, Pennsylvania. No one was hurt and the radiation contamination was confined to the main reactor, but public confidence in nuclear energy was shaken.[103]

Even before the Three Mile Island accident, the nuclear industry had been struggling to finance increasingly immense capital costs in the face of decreasing demand growth.[104] Higher costs, slackening electricity demand growth, and public concern over the safety of nuclear power plants sent demand for nuclear energy plummeting. The chief reason for the declining momentum was economic. Utilities had built large plants before much experience had been gained with small ones and often times expected economies of scale did not materialize.[105] Many units were forced to implement costly design changes and equipment retrofits after the Three Mile Island accident. In addition, nuclear power plants also had to compete with conventional coal- or natural gas-fired plants, which were gaining economies of scale and declining operating costs.[106]

After 1974, new orders for nuclear reactors plunged, and cancellations accelerated. No new orders have been placed in the U.S. since 1978. Moreover, 63 units were canceled between 1975 and 1980.[107] Eight reactors have closed since 1990, but increased productivity among the 103 remaining U.S. plants has raised nuclear electrical output by more than a third from 1990 to 2002. Nuclear energy currently provides over 20 percent of electricity generated in the U.S.[108]

To accommodate the increasing amount of spent nuclear fuel produced in the U.S., the Nuclear Waste Policy Act of 1982 (NWPA) was enacted in 1983. The NWPA established a program to build a repository for the disposal of high-level radioactive waste, including spent fuel from nuclear power plants. It provided for funding to be collected from the owners and generators of radioactive waste and spent fuel, enabling cradle-to-grave responsibility for nuclear fuels.[109]

103 United States Nuclear Regulatory Commission, "A Short History of Nuclear Regulation, 1946-1999."
104 Pietro S. Nivola, *"The Political Economy of Nuclear Energy in the United States."* The Brookings Institution, September 2004.
105 Department of Energy, "Energy in the United States 1635-2000: Nuclear."
106 *Ibid.*
107 Energy Information Administration, "U.S. Commercial Nuclear Power., March 1982.
108 Pietro S. Nivola, *The Political Economy of Nuclear Energy in the United States*.
109 Department of Energy Office of Nuclear Energy, Science & Technology, "History of Nuclear Energy., at http://www.nuc.umr.edu/nuclear_facts/history/history.html, accessed June 22, 2005.

## Alternative Fuels Slowly Develop

The Environmental Movement continued to gain momentum throughout the 1970s and the efforts to promote a cleaner environment were not lost on Congress, the industry, or consumers who voiced support for cleaner fuel choice options. Renewable energy resources gained market share through use of small-scale power generators allowed by PURPA's Qualifying Facility provisions. In addition, legislative incentives such as the Solar Energy Research Act of 1974, the Geothermal Energy Research, Development and Demonstration Act of 1974, the Renewable Resources Extension Act of 1978, and the Solar Photovoltaic Energy Research, Development and Demonstration Act of 1978 spurred technical research and development in a variety of renewable technologies.

In 1980, Congress passed a series of legislative initiatives designed to spur renewable energy development in the U.S. that amounted to $718.5 million in tax credits and research and development funds.[110] Some of the legislation passed that year included the Wood Residue Utilization Act, the Wind Energy Systems Act, and the National Energy Security Act of 1980 (which established the U.S. Synthetic Fuels Corporation Act), Biomass Energy and Alcohol Fuels Act, Renewable Energy Resources Act, Solar Energy and Energy Conservation Act and Solar Energy and Energy Conservation Bank Act, Geothermal Energy Act, and Ocean Thermal Energy Conversion Act. In response to these incentives, the renewable energy industry was able to grow and begin to emerge in the market. To further advance renewable energy resources, in 1981 Congress passed the Economic Recovery Tax Act (ERTA), which introduced the Accelerated Cost Recovery System (ACRS) and provided a 25 percent tax credit for renewable energy R&D.

Not all energy legislation passed in this period focused on renewable energy and conservation, as reliable sources of fossil fuels were still needed for many applications. In many Western States large amounts of oil shale existed that could be processed to provide oil for heating and industrial purposes as well as transportation needs. The U.S. Synthetic Fuels Corporation (SFC) was created through the 1980 Energy Security Act to initiate efficient oil shale projects. The SFC was touted as a forward-thinking government supported corporation that would move the oil shale markets forward in a strategic way. Policymakers rallied around the SFC and Congress allocated $15 billion in price guaranties and incentives for oil shale development to be awarded over several years.[111]

In 1981, OPEC's oil production was surpassed by non-OPEC oil producing countries and in the early 1980s oil prices fell, briefly reaching pre-1973 levels.[112] Reduced oil prices lessened the incentive to develop the large and costly oil shale processing plants, as surface operations required 2.5 tons of rock to produce one barrel of oil.[113] On May 2, 1982, Exxon's $5 billion Colony oil shale project in Western Colorado unexpectedly closed and resulted in stranded investments for the corporation and State and local governments. The oil shale industry eventually collapsed due to the dramatically fluctuating world oil price and conflicting resource development plans. The SFC closed its doors in 1986 and the projected success of the oil shale industry never materialized.

The falling price of oil also helped contribute to the abandonment of many renewable energy incentives. The Tax Equity and Fiscal Responsibility Act of 1982 (TEFRA) canceled the accelerations in the ACRS that had been mandated by the ERTA. TEFRA also reduced the base amount of capital costs to be recovered under the ACRS by amounts equal to any other qualifying tax credits a project may qualify for.[114] Energy tax credits were also canceled and the Tax Reform Act of 1986 repealed such incentives as the standard 10 percent investment tax credit and the tax-free status of Waste-to-Energy (WTE) power plants.

## 7.8 Energy and Environmental Policy Modifications: 1986 to 1999

Fuels policy evolved in the 1980s and 1990s as policymakers continued to consider what was in the best interest of consumers. The recent fluctuations in oil prices encouraged Congress to reexamine the state of fuel use policy and work to ensure that energy shortages be avoided in the future. This resulted in a series of amendments in both energy and environmental legislation.

## Hydropower Licensing Amendments

The Electric Consumers Protection Act of 1986 amended the Federal Power Act and was the first significant amendment to the hydroelectric licensing provisions of the FPA since 1935. Some of the relevant changes included; (1) the elimination of the municipal preference; (2) elevated environmental considerations in the licensing process; (3) PURPA benefits for new hydroelectric projects were eliminated unless the projects satisfied stringent environmental conditions; and (4) FERC's enforcement powers were increased dramatically

110 Michael J. Zucchet, "Renewable Resource Electricity in the Changing Regulatory Environment."
111 Russell George, "Testimony for the Senate Committee on Energy and Natural Resources."
112 Wikipedia – The Free Encyclopedia, "1973 Oil Crisis." at http://en.wikipedia.org/wiki/1973_energy_crisis, accessed June 22, 2005.
113 *Ibid.*
114 Energy Information Administration, "Legislation affecting the Renewable Energy Marketplace," at http://www.eia.doe.gov/cneaf/solar.renewables/page/legislation/impact.html, accessed July 12, 2005.

to give preference to State and municipal applicants when issuing original licenses for hydroelectric projects.[115]

## Clean Water Act Amendments

Environmental legislation, first enacted in the 1970s, was again the highlight of Congressional action during the 1980s and 1990s in response to increased demand by consumers to reduce pollution of the nation's air and water resources. The Clean Water Act (CWA) was amended in 1987 to create new programs to regulate toxins, increase the strength of water quality standards, and increase the enforcement options available to the EPA. In 1990 the oil spill provisions of the CWA were expanded in response to the Exxon Valdez spill off the coast of Alaska. The Alaskan oil spill led to public outrage and Congress quickly passed the Oil Pollution Act of 1990 (OPA 90), which extended the CWA by creating a separate program to govern oil spill liability and compensation.[116]

Since grandfathered power plants were exempt from many of the emissions restrictions of the Clean Air Act, Congress deliberated on how to revise the Clean Air Act to mandate stronger emissions standards. The result of these deliberations was the passage of the Clean Air Act Amendments of 1990 in which electric utilities were required to install Continuous Emissions Monitoring Systems, which measure each power plant's emissions of sulfur dioxide ($SO_2$), nitrogen oxides (NOx), and carbon dioxide ($CO_2$)117. The 1990 Amendments also set a goal of reducing NOx by 2 million tons from 1980 levels.118

The 1990 Clean Air Act Amendments also focused on cleaning up $SO_2$ emissions from coal-fired electric utility boilers with the inclusion of the Acid Rain Program, which embodied a results-oriented approach, flexibility in the method to achieve emission reductions, and program integrity through measurement of the emissions. The Acid Rain Program was the first significant attempt to use marketable pollution allowances, a cap-and-trade strategy, to reduce pollution from air emissions caused by fuel generated for electricity. By incorporating multiple emissions limitations into the Clean Air Act, the 1990 Amendments began an important shift toward cleaner fuels and providing industry with mechanisms to cost-effectively reduce emissions from existing sources.

The goal of the $SO_2$ emissions-trading program was to reduce aggregate national emissions to about half their 1980 levels by 2000, and to limit annual emissions to roughly 9 million tons thereafter. Pollution allowances were allocated to power plants. Compliance required each source to remit to the EPA allowances equal to their annual output of $SO_2$. Extra allowances could be "banked" for future use or sold on the open market.119 Tradable allowances encouraged firms to make cost effective investments in emissions reductions, as the allowances could be sold to other firms that were unable to reduce emissions cheaply.

The $SO_2$ program was implemented by the Environmental Protection Agency in phases, per the legislative mandate outlined in the 1990 Amendments. Initially power plants, mostly coal-fired plants with high emissions, were required to participate in the program. Phase two of the $SO_2$ program expanded coverage to include about 1,600 new units and reduced acceptable levels of $SO_2$. The net result of the Acid Rain Program was a dramatic reduction in $SO_2$ emissions in the U.S. and overall national air quality improved.120 Many analysts attribute the $SO_2$ program's success to the versatility of its market-based system, which allowed producers to follow vastly different strategies to meet the requirements, due to differing costs of pollution-abatement strategies.121

## Energy Policy Act of 1992

National fuels policy was also influenced by the passage of the Energy Policy Act of 1992 (EPAct). Enacted under President George Bush, EPAct was a comprehensive bill that reflected the dramatic changes in the electric power industry that had occurred as a result of PURPA. Creating a framework for a wholesale competitive electric power market, the EPAct established a new category of electricity producers, the exempt wholesale generators (EWGs). EWGs were not constrained by PURPA's regulations on utility electricity generation. The EPAct also mandated that FERC open the national electric transmission system, on a case-by-case basis, to wholesale suppliers. Being exempt from these barriers, EWGs experienced little trouble entering the wholesale electric production market.[122] EWGs tended to build natural-gas fired power plants that were cleaner than older, coal-fired facilities.

The EPAct also contained a number of incentives to encourage more production of energy from renewable resources, a one-step licensing process for commercial nuclear plants, efficiency standards for lighting, electric motors, heating,

115 Library of Congress; THOMAS – U.S. Congress on the Internet, "Bill Summary & Status for the 95th Congress - S.426 Public Law 99-495 (10/16/86)."
116 Sullivan, Thomas F. ed., *Environmental Law Handbook*. Rockville: Government Institutes, 2003.
117 Natural Resources Defense Council, *Risky Business: Hidden Environmental Liabilities of Power Plant Ownership, An In-Depth Report*, September 1996.
118 Environmental Protection Agency, "History."

119 "Highlights of the 1990 Clean Air Act Amendments," *EPA Journal*, January/February 1991.
120 David M. Driesen, "Testimony before the United States House of Representatives Committee on Energy and Commerce," Associate Professor, Syracuse University College of Law, May 1, 2002.
121 Federal Reserve Bank of Cleveland, "Economic Commentary: From Market Failure to Market Based Solutions: Policy Lessons from Clean Air Legislation," August 1, 2001.
122 Environmental Protection Agency, "Overview of the EPAct 1992," at http://www.eia.doe.gov/oil_gas/natural_gas/analysis_publications/ngmajorleg/enrgypolicy.html, accessed April 20, 2005.

and other appliances, and standards to increase the use of alternative fuels.[123] It was the most extensive piece of energy legislation since the National Energy Act of 1978.[124] EPAct reflected a desire by Congress to promote competition in wholesale electric markets and it further supported the expansion of renewable energy, energy conservation, and efficiency programs as alternatives to fossil fuel-based electric power generation. However, since the passage of the EPAct, the primary fuels for electric generation have continued to be dominated by coal, nuclear energy, and natural gas. Capacity factors in all three types of facilities have increased steadily since 1992 due to the increase in competitive forces driving the market, implementation of new technologies that improve the efficiency of the plants, and until recently, relatively stable prices.[125]

In its implementation of EPAct in 1996, FERC issued Order No. 888, which mandated that transmission owners who purchase service from others must offer nondiscriminatory transmission service to those seeking such services over its own facilities.[126] Order 888 ensured that all electricity suppliers, regardless of ownership structure, had access to the market and encouraged the creation of a Price Exchange to reveal market-clearing prices for electricity in the competitive market.[127] To further encourage the development of a free market, FERC issued Order No. 889 in tandem with Order 888, which required posting of available capacity on the Open Access Same-time Information System (OASIS).[128] These two FERC Orders firmly established the competitive wholesale electric marketplace, which relied on both fossil-fuel based generation as well as alternative fuel generation.

### New Natural Gas Initiatives

Natural gas use for stationary applications continued to expand its market share through the 1990s. Technological advancements such as new highly efficient gas turbines made it possible for utilities, and rapidly emerging non-utility generators, to build commercial-sized generating facilities at a lower cost than a comparable coal plant, with fewer air emissions and manufacturing facilities to rely on natural gas as a feedstock. Natural gas production, transmission and consumption have environmental externalities, but it is nonetheless the cleanest of the fossil fuels, based on current technologies.[129] Construction and permitting procedures of natural-gas fired power plants during the 1980s and 1990s took less time than comparable coal-fired facilities. Natural gas supplies were projected to be plentiful, a projection strengthened by the 1999 National Petroleum Council reports.[130] The decline of real wellhead prices by 51 percent from 1984 through 1992 reinforced this assumption and forced producers to reassess drilling and production activities to minimize the "bubble" of oversupply, which had plagued the industry since the mid-1980s.[131]

Natural gas supply remained stable throughout the 1990s, and most imports came from Canada, an ally of the U.S. By 2003, 300 new gas-fired plants had been constructed with investments totaling over $100 billion as utilities began to look toward gas-fired generation as a means of avoiding emissions restrictions that impacted coal-fired plants. Many coal-fired facilities found it economical to "fuel-switch" to natural gas to fire their turbines.[132] During this time period, policymakers embraced the wide shift to natural gas. Many fuels policy decisions in the States were based on the projection of abundant, stable-priced supply of natural gas.

## 7.9 Influential Fuels Policy Events: 2000 to 2005

### Natural Gas Shortages

Much to the surprise of policymakers, in June 2000, due to recent extraction reductions and the fact that the supply "bubble" masked the peak in domestic production insufficient temporary natural gas reserves resulted.[133] Fuel switching was minimal at this time due to soaring prices of substitute fuel options. Both oil and natural gas prices rose late in the year 2000.[134] From 2000 to 2001, the natural gas drilling boom of the 1990s dropped slightly at first, and then dropped dramatically. U.S. natural gas production had peaked in 1971 at 435 thousand cubic feet (Mcf) per well per day.[135] Canadian production of natural gas was also declining, forcing the U.S. toward increased production and

123 "President Signs Energy Bill," *Science News*, Nov. 21, 1992 v142 n21 p350.
124 Kim Cawley and Peter Fontaine, "The Energy Policy Act of 1992: A Budgetary Perspective," The Congressional Budget Office, Dec. 1992.
125 Eugene F. Peters, "Testimony Before the House Subcommittee on Energy and Mineral Resources," Vice President of Legislative Affairs, Electric Power Supply Association, July 16, 2002.
126 Federal Energy Regulatory Commission, "What is FERC: History."
127 *Ibid*.
128 An Internet bulletin board created by the Federal Energy Regulatory Commission to give energy marketers, utilities and other wholesale energy customers real-time access to reserve capacity on the U.S. electrical transmission grids. Formerly referred to as the Real-Time Information Network.
129 Shepard Bliss, "Natural Gas—The Next Fossil Fuel Shortage," *Energy Bulletin*, June 28, 2005.
130 National Petroleum Council. "Natural Gas: Meeting the challenges of the nation's growing natural gas demand," at http://www.npc.org/reports/ReportVol1.pdf, accessed July 12, 2005.
131 Energy Information Administration, *Natural Gas 1994: Issues and Trends, July 1994*.
132 *Ibid*.
133 Gas demand generally peaks in the summer and decreases in winter. Therefore, in the off-months, excess gas imports are typically stored in underground tanks to hedge against future seasonal increases in demand.
134 Fred Sissine, "Renewable Energy: Tax Credit, Budget, and Electricity Production Issues," CRS Issue Brief for Congress. Updated December 1, 2004.
135 Energy Information Administration, "Energy in the United States 1635-2000; Natural Gas," at http://www.eia.doe.gov/emeu/aer/eh/frame.html, accessed July 7, 2005.

offshore imports of liquefied natural gas.[136] In 2002 LNG made up five percent of net natural gas imports to the U.S. and the Energy Information Administration estimated that that figure would grow to 39 percent by 2010. The growth in LNG imports is complicated by a shortage of LNG facilities—there are only five such facilities in the U.S.—resulting in severely limited LNG storage capacity.[137] Policymakers have been debating the course that the nation should take with regard to natural gas production generally, and LNG imports specifically since this time period. Controversies over the siting of LNG port facilities and concerns about "not in my backyard" have complicated the LNG debate.

## Renewable Fuels Developments

The terrorist attacks of September 11, 2001, and the Iraq war have led to heightened concern about U.S. energy security and energy infrastructure vulnerability.[138] Events such as the 2001 electricity shortages in California, the Northeast blackout of August 14, 2003, and the increasing worldwide emphasis on climate change have also increased interest in renewable fuels.[139]

A primary driver behind renewable energy research and development today is the desire by policymakers for the United States to implement a national fuels policy that promotes fuel supply options and reduced dependence on imported fuels. Government funding, as well as tax credits and other financial incentives, continue to flow to renewable energy R&D.[140] However, the private sector, including utility owners and independent power producers, has wrestled with the high upfront capital costs of renewable technologies, coupled with transmission grid access concerns.[141] Because many renewable energy technologies are based on intermittent supply, e.g., wind and solar power, as discussed in detail earlier in this report, their reliability cannot be counted on for baseload generation. Hydropower and biomass technologies have a relatively stable supply stream, though biomass technologies are not yet competitive in the marketplace and most available hydropower has been developed (though new technology may increase the capacity of existing hydropower facilities in the coming years). Technical advancements are expected to allow other, non-hydro renewable energy sources to become more economically competitive by 2025.[142]

Wind power has grown substantially over the past several years due to technology advances, high prices and shortages of natural gas, and the continued desire for clean technologies.[143] The development of wind power has also been highly dependent on policy levers, which include tax credits and investment incentives. The Production Tax Credit, which provides credits based on the amount of energy produced each year, has been especially influential in the development of the wind power industry. The PTC went into effect as part of the Energy Policy Act of 1992 to spur development of wind power. Initially set to expire in 1999, the PTC was extended several times, although it had also expired several times before being renewed.[144] This sporadic history has led to a boom-and-bust cycle of wind project development as installations have peaked when the PTC was in effect and lagged in other years due to uncertainty about policy.[145]

Advances in wind turbine technology have reduced the cost per kilowatt-hour of wind-generated electricity.[146] Some wind projects are selling energy at 3.5 cents per kilowatt-hour under long-term contracts—a price that can compete with the cost of electricity generated by natural gas-fired power plants.[147] However, wind power also has negative impacts, including aesthetics, wildlife and noise impacts, and its intermittency, which requires backup power, as discussed earlier.

## Oil Developments

In 2000, Congress authorized the establishment of the Northeast Home Heating Oil Reserve. The two million barrel reserve was developed on the projection that such an amount would be needed to meet the Northeast region's need for heating oil for a ten day period in time of emergency or extremely high demand. Congress also levied a fee of 2 cents per gallon on purchases of heating oil to fund research and consumer education on heating oil.

Additionally, in response to the attacks of September 11, 2001, President Bush directed that the Strategic Petroleum Reserve be filled at a moderate rate using royalty in-kind crude from the U.S. Outer Continental Shelf leases. As of the publication of this report, the SPR is at 686.5 million barrels.[148]

136 Energy Information Administration, "Consumer Price Estimates for Energy, 1970-2000," at http://www.eia.doe.gov/emeu/aer/txt/ptb0303.html, accessed June 22, 2005
137 Energy Information Administration, "U.S. LNG Markets and Uses" June 2004 Update.
138 Fred Sissine, "Renewable Energy: Tax Credit, Budget, and Electricity Production Issues."
139 *Ibid.*
140 *Ibid.*
141 Karen Palmer and Dallas Burtraw, "The Environmental Impacts of Electricity Restructuring: Looking Back and Looking Forward."
142 *Ibid.*
143 Natural Resources Defense Council, *Risky Business: Hidden Environmental Liabilities of Power Plant Ownership, An In-Depth Report*.
144 The Energy Policy Act of 2005 once again extends the PTC.
145 National Renewable Energy Laboratory, Policy and Market Factors Driving Wind Power Development in the United States, NREL/TP-620-34-599, July 2003.
146 DOE Energy Efficiency and Renewable Energy, "Wind Energy Fact Sheet," at http://www.eere.energy.gov/consumerinfo/factsheets/ad2.html, accessed April 25, 2005.
147 *Ibid.*
148 DOE, "Strategic Petroleum Reserve Inventory," accessed April 7, 2006.

## Energy Policy Act of 2005

The Energy Policy Act of 2005, signed into law by President Bush on August 8, 2005, was the most comprehensive energy legislation considered by Congress since the Energy Policy Act of 1992 was enacted. The Energy Policy Act of 2005 authorizes programs directed toward energy production, conservation, research and development, and will have great impact on national fuels policy for the next several decades. The Act includes provisions to help alleviate the nation's increased dependence on foreign oil, thereby helping both the economy and national security. In addition, the Act includes many provisions for fuel related issues, including clean coal research, programs to ensure nuclear energy contributes significantly to the nation's energy supply, stronger requirements for Federal vehicle fleets to use alternative fuels, research on the production, storage, and distribution of hydrogen, and incentives for natural gas production from the Gulf of Mexico.[149]

Earlier versions of the Act contained several provisions on fuel use that did not make it into the final version. One such provision was the Renewable Portfolio Standard (RPS), which would have required 10 percent of all electricity to be produced from renewable energy sources by 2020. The RPS was highly contentious. Critics argued it would have cost utilities and consumers an estimated $18 billion; supporters argued that the additional cost would have been defrayed by reduced spending on natural gas and other fossil fuels.[150] Another provision from an earlier Senate bill would have cut oil imports to 40 percent by 2025 from the current 58 percent, an equivalent to a reduction in foreign oil imports by 7.5 million barrels per day.

## The Clear Skies Act and Related Environmental Rules

The Clear Skies Act of 2003 was patterned after the Acid Rain cap-and-trade program stipulated under the CAA, and provided for the same market-based approach for multi-pollutants.[151] The Clear Skies Act legislation mandated caps on sulfur dioxide, nitrogen oxide, and mercury, and was introduced by President George W. Bush to be the "Clean Air Act of the 21st Century."[152] However, the Clear Skies Act stalled in the Senate Environment and Public Works Committee in early 2005 and Congress does not plan to reconsider the legislation during the 109th Congress. In its place, on March 10, 2005, the EPA released the Clean Air Interstate Rule (CAIR), the first part of the Clean Air Rules of 2004—a group of five rulemakings from EPA designed to "make the next 15 years one of the most productive periods of air quality improvement in America's history."[153] There are five major rules, four of which apply to fuels used for stationary power and three of which attend to the transport of pollution across State boundaries.

### The Clean Air Interstate Rule

According to EPA, CAIR is expected to create the largest emissions reduction in a decade by reducing sulfur dioxide and nitrogen oxide emissions in the Northeastern States by an estimated 70 percent and 60 percent (of 2003 levels), respectively.[154] CAIR is to be implemented in 28 Eastern States and the District of Columbia. It was enacted to respond to the unique atmospheric pattern present in these States where the downwind weather pattern can send particulate from one location to a location hundreds of miles away, making emissions reductions urgent.[155] States have two options for reduction: (1) use an interstate cap-and-trade emissions program; or (2) meet their individual emissions target on their own. With an interstate cap-and-trade emissions program, a Northeastern limit on emissions would be set. This limit would then be divided into a number of pollution permits to be allocated among the different States. Depending on States' pollution levels and marginal costs of abatement, trade will occur among States so that the pollution will be cleaned up in an affordable manner. If States choose not to take part in this program, they must meet their individual emissions target through a means of their choice.

### The Clean Air Mercury Rule

The second of these rules, the Clean Air Mercury Rule (Mercury Rule), was issued on March 15, 2005.[156] The Mercury Rule was designed to reduce mercury emissions from coal-fired power plants with the same market-based mechanisms as CAIR (cap-and-trade or individual reduction). EPA states in its press release on the Mercury Rule, that "it is the first regulation to specifically call for reduction of mercury emissions from coal-powered plants both in the United States and worldwide and is expected to reduce mercury emissions from coal-fired plants by 70 percent."[157] Coal-fired power plants are the leading source of domestic anthropocentric mercury emissions. With recent

149 Energy Policy Act of 2005, (Public Law 109-58), signed into law August 8, 2005.
150 "Senate Votes for Companies to Produce More Power From Wind and Sun," *Dow Jones Newswire*, 2005.
151 Environmental Protection Agency, "Clean Air Interstate Rule," at http://www.epa.gov/interstateairquality, accessed June 20, 2005.
152 The White House, "Executive Summary – The Clear Skies Initiative," at http://www.whitehouse.gov/news/releases/2002/02/clearskies.html, accessed June 20, 2005.
153 Environmental Protection Agency, "Clean Air Rules of 2004," at http://www.epa.gov/cleanair2004, accessed June 20, 2005.
154 Environmental Protection Agency, "Clean Air Interstate Rule," at http://www.epa.gov/cair, accessed July 5, 2005.
155 Paul Frisman, "Clean Air Interstate Rule." Connecticut Office of Legislative Research, May 13, 2005.
156 Platts Power, "Clear Skies 2005 priority, EPA delays clean-air rule; Leavitt leaves," January 6, 2005.
157 Environmental Protection Agency, "Fact Sheet – Clean Air Mercury Act," at http://www.epa.gov/air/mercuryrule/factsheetfin.htm, accessed June 20, 2005.

health issues related to mercury, such as numerous studies showing the neurological damage caused by mercury in fetuses and young children, action on mercury regulation has been long awaited.[158] However, there are many opponents to the Mercury Rule and litigation on this rule is expected.[159] As of the publication of this report, 14 States, various groups of clean air and public health advocates, several Indian tribes, and others have filed legal challenges in Federal court on the EPA's approach for reducing toxic air emissions from power plants. Rather than adopt a rule that limits mercury pollution, the petitioners contend EPA unlawfully removed power plants from the list of industrial pollution sources for which the Clean Air Act requires strong air toxic standards.

### The Ozone and Fine Particle Rules

The Ozone Rule and the Fine Particle Rule designate areas that violate ozone and fine particle standards, respectively. Ozone particulate and fine particles, particles with a diameter of 2.5 micrometers or less,[160] have been associated with serious health problems.[161] Particulate matter has also been found to lead to health problems and is emitted from many sources, including power plants.[162] Fine particulates can be formed in the atmosphere from various power plant-emitted pollutants. The two rules are extensions of the National Ambient Air Quality Standards (NAAQs) associated with each particle. Both rules are the final part of the NAAQ designation process, in that they designate the areas that are in compliance and those violating standards set by NAAQs. Those areas found in violation of standards are called non-attainment zones and are required to submit plans for pollutant reduction.

### Regional Greenhouse Gas Initiative

On December 20, 2005, seven States announced an agreement to implement the Regional Greenhouse Gas Initiative (RGGI), a multi-State regional initiative to design and implement a flexible, market-based cap-and-trade to reduce carbon dioxide emissions from power plants in the Northeast. The RGGI agreement was signed by the Governors of Connecticut, Delaware, Maine, New Hampshire, New Jersey, New York, and Vermont. The RGGI agreement calls for the framework for a Model Rule to be developed. The draft Model Rule was issued on March 23, 2006 and stakeholders and the public will have the opportunity to comment. The RGGI process for implementing a program for carbon capture in the Northeast is a model program that both the Congress and other States will watch closely.

## Conclusion

Fuel use in the United States has been influenced by a wide range of historic events, political movements and policy decisions that reflect changes in major trends of social priorities. The Industrial Revolution showcased the spirit of the entrepreneurs that developed the necessary technology to utilize fuels for stationary applications. The industry that grew up around these developments warranted Federal attention after the Great Depression and Federal energy policies began to emerge to protect consumers.

Events on the world stage influenced consumer opinion in the late 1960s concerning the quality of the environment and Federal policymakers responded with legislation that addressed many of these issues. The influence of this legislation on the use of fuels for stationary sources continued to evolve, as policies grew stricter over time. As environmental restrictions grew to be larger burdens on industry, policy tools based on market principles began to replace the command-and-control policies of early environmental legislation. Market based legislation was also implemented in Federal energy policy, as many industries began to transition to deregulated operation.

These trends have brought energy and environmental policies to where they are today. Primary themes include (1) the need for comprehensive energy regulation that takes environmental factors into account, (2) the importance of the elimination of loopholes that can lead to price gouging or environmental degradation that will harm consumers, and (3) the current success of market-based mechanisms, which tend to increase efficiency and benefit both consumers and industry. In understanding the rationale behind previous legislation and energy policy and the lessons learned from it, this chapter sets the predicate for the future use of fuels that is the main theme of this CECA report.

158 Environmental Protection Agency, "Health Effects," at http://www.epa.gov/mercury/effects.htm, accessed June 20, 2005.
159 ICF Consulting. "U.S. EPA's Proposed Clean Air Interstate and Mercury Rules Take Center Stage in Multi-Pollutant Debate," *IFC Perspectives*, Summer 2004.
160 Environmental Protection Agency, "Fine Particle (P2.5) Designation," at http://www.epa.gov/pmdesignations/index.htm, accessed June 20, 2005.
161 Environmental Protection Agency, "AIRNow," at http://www.epa.gov/airnow/ozone2.html#3, accessed June 20, 2005.
162 Ozone and particle exposure has been associated with decreased lung function, aggravated asthma, lung inflammation, chronic lung diseases, and permanent lung damage.