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Industry Study

Final Report
Energy Industry

The Industrial College of the Armed Forces
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ENERGY 2007

ABSTRACT: The national well being of the United States starts with energy security. In an expanding and interrelated global economy it is paramount that the United States develop and execute a national energy policy which is integrated as a key component of the National Security Strategy. This policy must address energy supply stability, support infrastructure improvements, promote greater use of nuclear power, and reduce hazardous emissions through the development of cleaner burning technologies and use of alternative fuels. Specifically, the national energy policy should lead to one air quality standard for automobile emissions, articulate a clear position on reducing greenhouse gas emissions, increase the diversity of fuel supplies through the continued promotion of alternative energies, foster intensive research and development on clean coal energy technologies, expand coal to liquids and coal gasification, expedite the approval process for liquid natural gas terminals, expand integrated natural gas infrastructure, tax nuclear waste to reduce its production, and energize the establishment of the national nuclear waste storage facility at Yucca Mountain. To address these issues, the 2007 Energy Industry Seminar Team traveled domestically to California and internationally to France and the United Arab Emirates to assess and analyze energy producers, distributors and regulators. This report details that research and analysis and explains specific the policy recommendations list above.

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PLACES VISITED

Domestic Travel

Constellation Energy Group, Lusby, MD
Wheelabrator Technologies Clean Energy Plant, Baltimore, MD
BP Solar, Frederick, MD
H2Gen Innovations, Inc. Alexandria, VA
The Stella Group, Arlington, VA
Mirant Dickerson Coal Power Plant, Dickerson, MD
Consol Corporation, Morgantown and Wanna, WV
Chevron Corporation, San Ramon, CA
Valero Refinery, Benicia, CA
Pacific Gas and Electric Company, San Francisco, CA
California Public Utilities Commission, San Francisco, CA
NRDC, San Francisco, CA
Capstone Turbine Corporation, Chatsworth, CA
Exxon Mobile Corporation, Harmony Platform, Santa Barbara, CA

International Travel

International Energy Agency, Paris, France
Gaz de France, Paris, France
Reseau de Transport d'Electricité, Paris, France
Electricity de France, Paris, France
TOTAL, Paris, France
Embassy Briefing, Abu Dhabi, UAE
UAE Minister of Energy/OPEC President, Abu Dhabi, UAE
Abu Dhabi National Oil Company, Abu Dhabi, UAE
Dolphin Project and MASDAR Initiative
Exxon Al-Khaleej, Abu Dhabi, UAE
Abu Dhabi National Energy Company TAQA, Abu Dhabi, UAE
Taweelah Power Plant, Dubai, UAE
Mac McClelland, Center House Limited, U.S. Consulate, Dubai, UAE
Caltex, Chevron Corporation, Fujairah, UAE

KEEP THE FLAME BURNING

1. Introduction

Energy is crucial to protecting the United States' national security interests. Indeed, it is hard to overemphasize the importance of a reliable, affordable energy supply as a critical lifeline for practically every aspect of the nation's vibrant economy. Energy supports the nation's industrial base, ensures the progress of technological advances, and improves the comfort of its citizens. This nation's ability to access, store, produce and process energy has made it the world's preeminent economic and military super power. Unfortunately, this love affair with energy could also be the nation's most significant national security vulnerability. Consider that over 85% of the nation's energy comes from fossil fuels, 60% of which are imported, often from volatile areas in the world and from cartels that can easily influence world petroleum markets and prices. Further, toxic emissions from burning fossil fuels are contributing to a global environmental crisis that could result in horrendous diseases, mass migrations, and economic upheaval.

This report discusses the five U.S. primary energy sectors, identifies their current key issues, provides future assessments, highlights ways to reduce carbon dioxide emissions, and proposes recommendations to build energy self-reliance. It then proposes specific policy measures to increase production of nuclear energy, reduce dependence on foreign oil, promote clean burning alternative sources of fuel and increase available energy sources through efficiency and conservation.

This report's analysis relies upon an array of sources extending well beyond authoritative literature. It also includes valuable information received from U.S. and foreign private industry leaders, government policy makers and regulators, and academic experts at various lectures and site visits attended by the ICAF Energy Industry Study Team (EIST). The net result of these academic experiences was an acute appreciation for the enormous contribution of human capital, government policies, as well as public and private investment that make up the energy industry. From the man working in the West Virginia Coal mine to the woman in Fujairah, UAE, coordinating the flow of jet fuel to U.S. fighter pilots in the Persian Gulf, every person in this complex system plays a role in making sure America's energy needs are met. Policy makers, who play an important part in implementing the national energy policy, should ensure the recommended policy objectives are obtained.

2. The Energy Industry Defined

The five primary energy commodities of petroleum, coal, natural gas, nuclear power and renewable products make up the complex energy market. The greatest market demands for energy consumables (in descending order) are electrical power generation, transportation, industrial use, and residential consumption and commercial applications. (Figure 1) The dominant providers for this energy are petroleum and coal, collectively providing over 63% of the nation's energy supply while natural gas, nuclear electric power and renewables contribute only 37% (Energy Information Agency (EIA), 2006, Annual Energy Review, Tables 1.3 and 2.1b-2.1f).

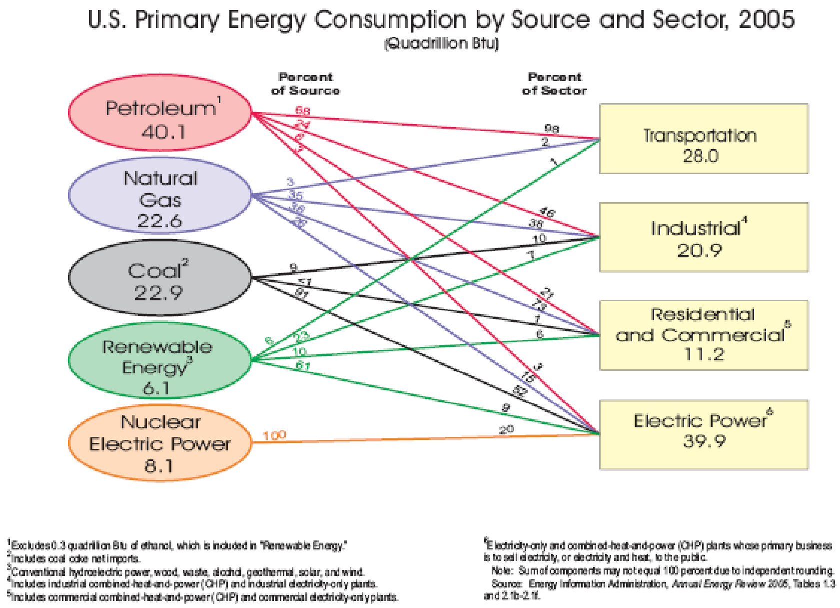


Figure 1: U.S. Primary Energy Consumption by Source and Sector

a. Petroleum

Pros:

- Cost-effective transportation fuel (compared with alternatives)
- High energy density
- Basis for important petrochemical industry

Cons:

- Reliance on imports from volatile regions
- Greenhouse gas emissions

Policy Recommendations:

- Limit number of fuel blends to remove refinery bottlenecks
- Increase *diversity* of fuel supply through development of alternative fuels

Over the last few decades, the world oil market, and the United States' place within it, has undergone many changes, as seen in Figure 2 below. While world oil consumption has increased, so has the rate of production and the amount of proved reserves. Within the United States, oil consumption has continued to rise, with a marked shift to reliance on imports.

World Oil Statistics	**1970**	**1985**	**2005**
World Oil Average Price ($/barrel, 2005 $US)	$12	$43	$55
World Oil Production (million barrels/day)	47.9	59.2	83.8
World (conventional) Proved Oil Reserves (billion barrels)	620.7	705.0	1292.0
Reserve "life" (Years) = Reserves/Production	35.5	32.6	42.2
U.S. Oil Statistics	**1970**	**1985**	**2005**
U.S. Oil Consumption (million barrels/day)	14.7	15.7	20.7
U.S. GDP ($billion, 2005 $US)	4276.8	6464.0	12621.1
U.S. Consumption/GDP ratio	34.4	22.9	16.4
U.S. Oil Imports (% of consumption)	22%	27%	60%
U.S. oil consumption by sector:			
- Transportation	51.8%	64.6%	66.9%
- Industrial	25.4%	26.9%	24.4%
- Other	22.8%	8.5%	8.7%

Figure 2: World and U.S. Oil Statistics
Adapted from Darmstadter (2006)

The upstream sector of the oil market, which consists of exploration and production of crude oil, is driven by several dozen private and national companies. Even with OPEC's 40% share of world oil production, the oil market remains competitive, where crude oil is a fungible commodity which will be sold anywhere in the world to meet the highest demand. The downstream sector consists of refining crude oil into final products, along with marketing and delivery of these products. Refineries are huge, complex operations which require large capital investments. A combination of high initial costs and low potential for high profit margins act as a barrier to entry of new firms into the market. The delivery and sale of refined products to customers operates competitively, where fuels and lubricants are delivered by thousands of retailers, making it easy for customers to migrate to the cheapest price.

The use of oil products is dominated by the transportation sector, primarily by gasoline, diesel, and jet fuel. Today, 67% of oil consumed in the United States goes to transportation fuels, followed by industrial uses at 25%, residential/commercial uses at 6%, and electricity generation at only 2.5% (Annual Energy Outlook, 2007). In 2005, the United States imported the most oil of any nation with 13.5 million barrels/day (mmb/d), a 53% increase from a decade earlier. As for exports, the region with the largest percentage increase was Europe, led by the former Soviet Union countries, whose 2005 exports of 9.2 mmb/d more than doubled their total from 1995. Nonetheless, the Middle East still dominates the export market, accounting for 40% of all world exports in 2005 (BP statistical review, 2006). However, perhaps within an eye toward a future where such market domination changes, the EIST learned during its meetings with the UAE Energy Minister, Abu Dhabi National Oil Company, and others, the UAE in particular is using its large oil revenues to invest in other segments of its economy with the eye towards long-term, sustainable economic growth.

While today's oil market demand is dominated by the mature, industrialized nations of the world, this will change over the next 25 years. While global oil demand is expected to grow nearly 50% by 2030, from approximately 85 mmb/d to 120 mmb/d, most of the growth is expecting to come from emerging countries such as China and India. This continues recent trends, where China and India increased their energy consumption from 1995 to 2005 by a whopping 106% and 57% (BP statistical review, 2006). To meet this soaring demand, the oil industry is expected to expand existing production facilities to increase output. In addition, the industry will also find and exploit more expensive oil supplies such as oil sands and oil shale. All of this will require large investments by both state-owned and private oil companies, estimated to exceed $110B/year and total $3 trillion by 2030 (Tomorrow's Energy, 2006).

Analysis indicates that despite the proliferation of the Hubbard's Peak theory advocating more than 50% of the world's oil has been recovered, the world is <u>not</u> running out of oil anytime soon. (Hubbard's Peak Warning, April 2005) Adequate oil reserves are available to meet growing demand. Almost 80% of the world's known oil supplies are still available for use, with only 20% (about 1 trillion barrels) having been consumed.

Emphasized during a visit to a Valero refinery in California, the nation's refineries today serve as a serious bottleneck that threatens the viability of the overall oil products supply chain. In fact, the last refinery built in the United States was 1976. From 1981 to 2005, the total number of refineries fell from 324 to 132, while total refining capacity fell from 18.6 mmb/d to 16.8 mmb/d (Clayton, 2005). To compensate for growing demand, companies have increased the efficiency and capacity of existing refineries. A related concern is the fragmentation of the refined product market. The refinery industry is splintered by the production of over 50 different fuel blends designed to meet emission requirements unique to specific localities, which prevents gasoline from being fungible between regions of the country.

To reduce these inefficiencies in the system, the federal government should limit the number of fuel blends to a much smaller number of variants that are capable of meeting most, if not all, of the emission requirements across the nation. Also, effective incentives should be provided to assist the refinery owners in making infrastructure changes needed to facilitate the shift in fuel blend production at their facilities, as well as to provide proper incentives to enable an increase in overall refinery capacity to meet our nation's critical needs. This is more consistent with the philosophy in the European Union (EU), as the EIST gleaned during a visit to the International Energy Agency in Paris. There, the team learned that the EU has one set of fuel refinery standards and therefore does not have this bottleneck problem experienced in the United States. As a result, gasoline produced in one EU country can be sold in any of the others.

While the EIST found the focus of energy security in France to be similar to that in the United States, the EIST found the philosophy of energy security in the UAE to be much different, likely due to the UAE's status as a major oil exporter. Accordingly, the UAE focuses on *security of demand* for its exports. During the team's meeting with the UAE Minister of Energy (also the president of OPEC), he reiterated his country's position that oil is a long term resource, which the country will exploit at a steady pace to support the nation's long-term needs.

b. Coal

Pros:

- Abundant domestic supply
- Historically stable price
- Provides large number of jobs

Cons:

- Substantial environmental impacts
- Capital intensive
- Tied to limited transportation infrastructure

Policy Recommendations:

- Continue intensive R&D on clean coal technologies
- Expand capabilities: ecologically sound *coal to liquids* and *coal gasification* processes

Coal is the most abundant fossil fuel in the United States, providing over 50% of domestically produced electricity, and amounts to a $200 billion industry. Environmental

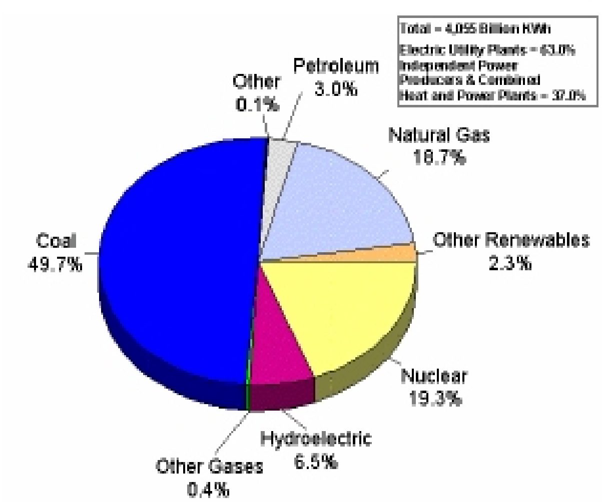
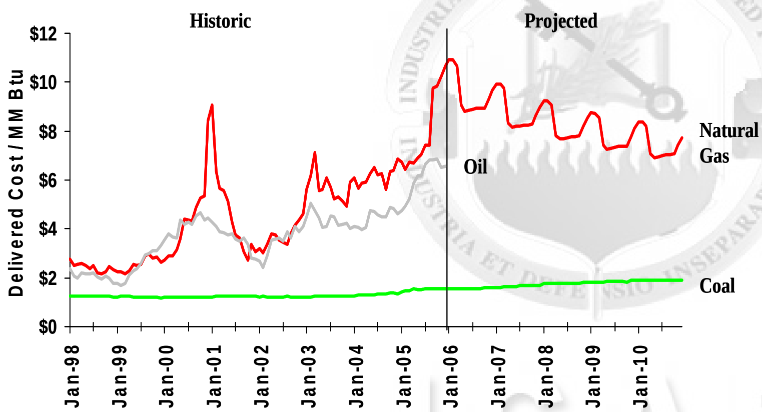


***Figure 3:** Electrical power generation by fuel* **(**Monthly Energy Review, February 2007)

regulation looms as the largest pitfall to the future viability of the coal industry. Unfortunately, burning and processing coal emits carbon dioxide (CO_2) and other gasses. Although coal producers have made great progress in limiting nitrous oxide (NO_X) and sulfur dioxide (SO_2) emissions, CO_2 emissions remain an area of great concern as scientists are increasingly certain that CO_2 contributes to the greenhouse affect, which is resulting in the warming of the planet. During the EIST visit to California, industry and governmental sources underscored the "unattractiveness" of coal-fired electric generation—indeed a ban on such power currently exists in California. To reign in CO_2 emissions, policy makers have considered imposing a carbon tax or implementing so-called "cap and trade" mechanisms, both which are aimed at reducing CO_2 emissions. Scientists are also researching carbon sequestration programs and are developing a coal-powered power plant that will not emit any CO_2 gasses. All of these programs are still in the developmental phase and will not substantially reduce CO_2 emissions for years to come.

U.S. coal mining is a robust and profitable business. Coal demand remains strong, supplies are domestically available and prices have remained relatively constant, making it an attractive energy commodity (Figure 4). Comprised of over 250 companies, operating 1400 mines in 26 states, coal firms employ over 80,000 people and contribute both directly and indirectly to over $200 billion annually to the U.S. economy (Holmes, 2007, March 8, slide 7). Moreover, coal production has grown historically and is projected to increase by 49% by 2030.



Delivered cost of fossil fuel at steam electric utility plants.
Source: Energy Information Administration, Electric Power Monthly and December 2004 Short-Term Energy Outlook. NYMEX HH Futures closing price for January 2005.

Figure 4: *Historic Cost and Projected Cost of Coal* (Electric Power Monthly, December 2004)

A key component to keeping coal attractively priced is continued technological advancement. Historically, technology has led to tremendous productivity increases. The long wall mining technique used in underground mines and the amplified use of large and sophisticated machinery in open pit mining has significantly improved productivity over the last 20 years. Technological machinery advances contribute most specifically in open cut mining which is typical of coal mining in the western United States where mining is 2.7 times more productive than underground mines and accounts for over 67% of total coal production (IBIS World, 2006, December 22, pg. 16). Technological advances in long wall mining focus on obtaining a more complete extraction of coal from the mine, leading to better efficiency. As compared to other mining, underground methods typically provide 15-25% greater yield (IBIS World, 2006, December 22, pg. 16). Regardless of the advances in technology and efficiency, the industry's need for additional human capital was reiterated time and again, by both industry experts in Washington, D.C. as well as in the coal fields of West Virginia during the EIST visit. The industry predicts the need for an additional 35,000 workers by 2030 to meet growing demand. Technological advances are encouraging but additional improvements are also needed in the coal distribution system.

Coal is not easily moved and is tied to user markets by transportation systems operating near their maximum capacity. Over two-thirds of all coal is distributed by America's aging railroads and is vulnerable to freight fatigue or interruption (EIA, 2007, February, pp. 38-40). The cost of improving this nation's railroads and additional equipment purchases are passed along to the consumer. High transportation costs are the primary reason for coal imports to the United States. With low cost and high efficiency ocean transport, it can be less expensive for eastern seaboard power plants to import certain amounts of coal from South America than to pay for the transport of coal via rail from the western United States. This phenomenon led to an estimated importation of 32 million tons (or roughly 2.8% of consumption) of coal into the United States in 2006 (IBIS World, 2006, December 22, pg. 10).

The United States has far greater reliance on coal as a source of electricity power than either of the two countries visited by the EIST. In the mid-1970s, France chose to pursue nuclear power as its major electrical base-load generation capacity. The UAE has chosen natural gas due to its abundance in the area. If the United States decides to pursue the increased use of coal to meet its increasing electrical base-load needs, then the U.S. must address the environmental externalities raised by the use of coal.

The coal industry remains robust but faces some significant challenges, such as governmental regulation, hazardous CO_2 emissions, as well as a restricted and increasingly encumbered transportation system. Coal has been an exceptional energy provider; however, despite bright long term projections, coal will have to become leaner, cleaner and greener to retain its massive market share.

c. Natural Gas

Pros:

- Relatively affordable, abundant natural resource
- Less CO_2 emissions than other fossil fuels
- U.S. reserves can meet next 50-75 years of demand

Cons:

- Infrastructure not keeping up with growth in demand and deterioration
- Regulatory uncertainty; exporter and importer price regulation and subsidization
- Nationalization of resource increasing, affecting production

Policy Recommendations:

- Remove regulatory barriers to access to reserves
- Expand/build integrated natural gas infrastructure
- Expedite process to approve LNG terminals

The demand for natural gas "has accelerated in the United States over the last several years due to environmental concerns about other energy sources, widespread building of natural gas-fired electricity generation, and low natural gas prices through the 1980s and 1990s" (Parfomak, 2007, p. 3). As a result, the use of natural gas has grown to approximately one quarter of the nation's total energy consumption and demand is expected to increase by 22% between 2007 and 2030 (AEO2007, p. 89). Concurrent with the growing derived demand for natural gas has been the escalating price of natural gas, increasing levels of imports, abundant yet untapped recoverable natural gas resources, and delayed infrastructure development

From 1995 to 2005, the Henry Hub[1] price for natural gas increased from $1.69 to $8.79 per million Btu (BP, 2006, p. 31), approximately a 520% increase. Simultaneously, the end of 2005 saw global production equaling 97,533.9 trillion cubic feet (Tcf) and consumption equaling 97,060.88 Tcf, the delta being 0.473 Tcf or 0.4% of total production. This tight supply/demand balance, challenged by a global low marginal spare capacity, is evident in the U.S production shortfall. Over the same time period the United States evolved from meeting 100 of its demand with national production to relying on 19% of its consumption coming from imports. 85% of our dry gas comes from Canada while the remaining 15% is LNG imports from mainly Trinidad and Tobago, and small amounts from Algiers, Egypt, Nigeria, Malaysia, Qatar and Oman (BP, 2006, p. 30). In 2005, the United States consumed 22,367.5 Bcf and produced 18,557.21 Bcf of natural gas.

The United States relies on natural gas as an energy source for the majority of its industrial, commercial, residential and some electric power generation requirements. Natural gas is consumed in the United States mainly by the industrial (35%), electric power (24%), and residential and commercial (36%) sectors. This reliance, gas's substitutability with oil, global low marginal spare capacity, and regional versus global markets have significantly contributed to the rise in natural gas prices. The regional markets prevent a fungible product and create various price markets. Interestingly, the United States continues to import natural gas to sustain its demands despite having an abundant amount of recoverable natural gas. The Energy Information Agency conservatively estimates that the United States has over 1,300 trillion cubic feet of recoverable natural gas—enough to meet current and projected demands for the next 50-75 years (Schmitt, 2006, p. 63) . Unfortunately, due to existing federal and state regulations and barriers, access is restricted on roughly 80% of the nation's the recoverable natural gas prospects, which are located in the Outer Continental Shelf, Deepwater Gulf of Mexico, Alaska North Slope, Arctic National Wildlife Refuge, the Rockies and Lower 48 states.

In addition to regulatory barriers, the United States is hampered by delayed infrastructure development. Specifically, pipeline and Liquefied Natural Gas (LNG) terminal construction has not kept pace with the growing demand. The beginning of 2005 revealed that the nation's natural gas transmission network slowed in expansion in both added transportation capacity and new pipeline mileage. Approximately 1,450 miles of pipeline and 7.7Bcf/d of natural gas capacity were added in 2004; the least amount of incremental capacity since 1999 (EIA, nd, p. 3). Consequently, the pipeline infrastructure is not keeping up with demand, anticipating future demand or proactively addressing aging structures. Furthermore, the United States has only five LNG receiving terminals, four onshore and one offshore, and one export terminal in Kenai, Alaska. The majority are located in the Gulf of Mexico with one on the Northeast coast and none on the west coast. Currently, government regulators have approved 20 LNG terminals within the United States, with three more in Mexico and Canada respectively. Additionally, another 19 terminals for the United States have been proposed (Hederman and Sweetnam, 2007, p. 25). Many, if not most, terminals have been delayed due to State efforts and some funding issues.

The number one recommendation is to reduce intervention by both the federal and state governments. The history of the natural gas industry clearly shows the maxim that intervention

[1] Henry Hub price is the standard industry price used in the United States for natural gas; it is also used as a common benchmark in other world markets.

begets more intervention. Second, state and local policy makers should expedite the process to receive approval to build LNG terminals. Third, the United States Government should build an expanded natural gas infrastructure off the existing drilling rigs, pipelines and terminals that would network existing and planned LNG terminals with not yet tapped proven reserves in the Outer Continental Shelf, Deepwater Gulf of Mexico and other large proven reserves. The corresponding result would be an abundant, diversified and sustainable supply of strategically secure natural gas for at least the next 50 years. All of this could be accomplished and online before nuclear or other energy capacity could be developed and implemented.

The EIST learned how France and the UAE are addressing natural gas issues within their individual countries, during a time where deregulation and unbundling of energy resources are an increasing trend. For example, in France, policy makers are concerned primarily with development of a natural gas distribution grid, growing LNG imports, Russian pipelines issues and the volatility of price between various European countries. In the UAE, construction was recently completed on the Dolphin natural gas pipeline, which will move natural gas from Qatar to the UAE. This highlights the UAE's plan to rely on natural gas, not oil, as its primary source for electricity and water production.

Natural gas is a critical resource necessary to support and sustain the nation's vibrant economy. Natural gas, both dry and LNG imports, is a vital national security resource, and will continue to be so for at least the next 20 years. Consequently, natural gas must be thoroughly integrated into the United States' energy policy and corresponding strategy. The U.S. legislative leadership must place the United States before the individual states and pursue harvesting the nation's own resources versus purchasing from abroad.

d. Nuclear Power

Pros:

- Low operating costs
- CO_2 regulations/taxes make nuclear power more price-competitive.
- Construction times for reactors have decreased to 36 months from 6-8 years.

Cons:

- High initial capital costs
- Licensing/regulatory processes are lengthy and burdensome
- Public concerns regarding operations and waste disposal

Policy Recommendations:

- Continue support for EPAct 2005 and building 6000 MW of nuclear power generation
- Tax nuclear waste production rather than the electricity produced
- Require future reactors have capability to burn waste
- Build a national storage facility at Yucca Mountain

Nuclear power has been providing electricity for the United States since 1957. Since then, the industry has grown to where it now consists of 103 nuclear reactors at 65 plants in 31 states and provides over 20% of the nation's electricity.[2] (Holt, 2007)

[2] International Nuclear Safety Center, Maps of Nuclear Power Reactors: United States, August 2005, retrieved 25 April 2007, from http://www.insc.anl.gov/pwrmaps/map/united_states.html

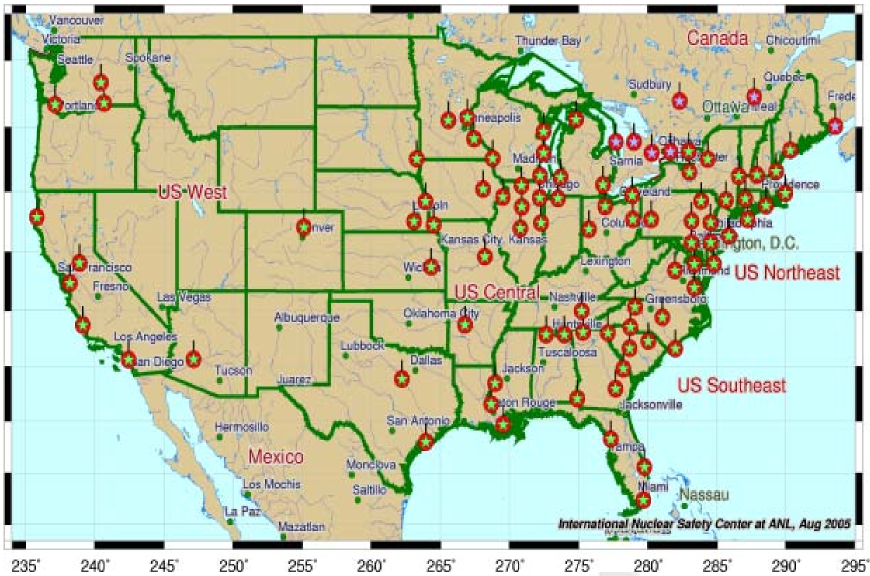


Figure 5. *Location of Nuclear Reactors in the United States*

No new nuclear reactors have been built in the United States for over thirty years and the national will to support nuclear power has eroded, along with the financial resources needed to promote its development. By the end of the 1980's, legislation, government oversight and the perceived risks associated with nuclear power generation reduced its economic viability bringing the industry to a standstill. As a result, the U.S. nuclear power generation infrastructure is aging, with most of its nuclear power plants at or near the end of their original life expectancy.

A variety of factors have made emission-free nuclear power more attractive. Power generation will experience a 50% increase in CO_2 emissions by the year 2030. Coal and coal fired heat plants are predominately responsible for this increase. (Figure 6, Matthes, F.C, 2005, P.12). Even though nuclear power has its own environmental issues associated with the disposal of non-radioactive water vapor, nuclear power is the only energy alternative that simultaneously addresses both global warming issues and base load concerns. (Environmental Effects of Nuclear Power, 2007). Of all the environmental issues associated with nuclear power, the most formidable challenge to overcome is that of waste management. The average 1000-Megawatt electrical (MWe) nuclear reactor creates about twenty five tons of spent fuel per year. Currently, spent fuel is processed, treated, packaged, and stored in temporarily holding facilities located near the reactor. The disposal portion of the waste management process represents one of the largest political challenges to the resurgence of nuclear power.

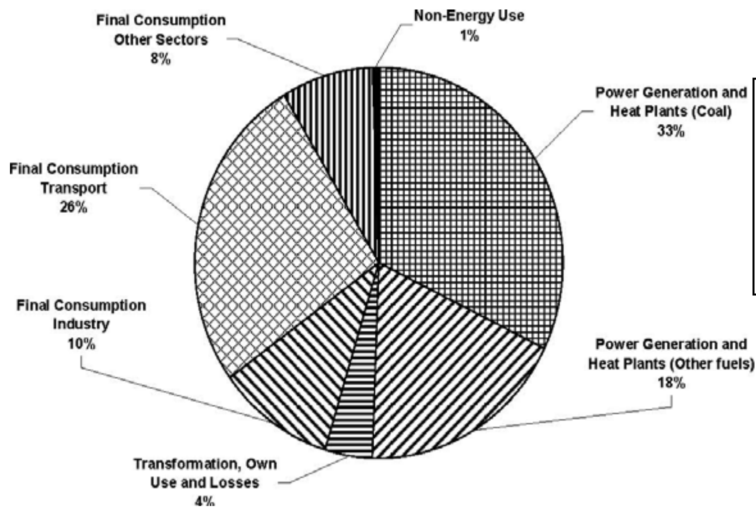


***Figure 6**: Breakdown of energy sources contribution to CO_2 emissions*

The National Energy Policy (NEP) 2001, established a framework for expanding nuclear energy use by simplifying and licensing new plants, extending current licensing, encouraging the design and development of next generation reactor designs, promoting research and development into advanced nuclear fuel cycles which can become more efficient and reduce long lived fission by-products (Lake, 2006). The policy also aimed at reducing the demand for waste storage at on-site locations and at the planned national nuclear waste repository at Yucca Mountain in Nevada. This issue will be further explored in the nuclear power highlight essay attached.

Nonetheless, initiatives such as the NEP and Advanced Fuel Cycle Initiative (AFCI) show that nuclear power has promise to fill this nation's energy needs. As an example, 80% of all electrical power in France is generated from nuclear reactors. The Energy Industry Study Team found that in France the challenge of hazardous waste disposal is met with a combination of deliberate planning that incorporates sophisticated reprocessing techniques to diminish the volume of waste and the establishment of three distinct national nuclear waste storage facilities (EDF Presentation, Paris France 6 May 2007). A recognized energy expert in the UAE, shared his analysis with the Energy Industry Study Team that the countries that comprise the Gulf Cooperation Council (GCC) will eventually migrate to the use of nuclear power for its electricity production, despite proliferation concerns raised by other countries.

By building upon the lessons learned in France and with careful government oversight, industry safely initiatives and market desire for clean safe power the nation can build a more capable and productive nuclear power grid. Greater roads ahead for the role of nuclear energy are discussed in the highlight essay, *Nuclear Power and the Environment.*

e. Renewables

Pros:

- Relatively low greenhouse gas/CO_2 emissions
- Increases diversity of energy portfolio
- Lower externality costs

Cons:

- High cost, still technologically immature
- Unintended consequences (like increased food prices or windmill bird strikes)
- Low surge capacity

Policy Recommendations:

- Continue subsidies/incentives to achieve a more competitive and diversified energy market
- Increase R&D initiatives
- Develop clear U.S. policy on greenhouse gas reductions

The final and key ingredient in the long term U.S. energy plan is the development of more efficient and cost effective renewable energy. Although these renewable energy sources have existed for many decades, technological barriers to their large scale acquisition, storage and distribution have undermined their value and contribution to the nation's energy needs. As reflected in Figure 7, renewable energy sources contribute only slightly over 6% of the country's energy requirements, with hydropower providing the lion's share for the production of electricity.

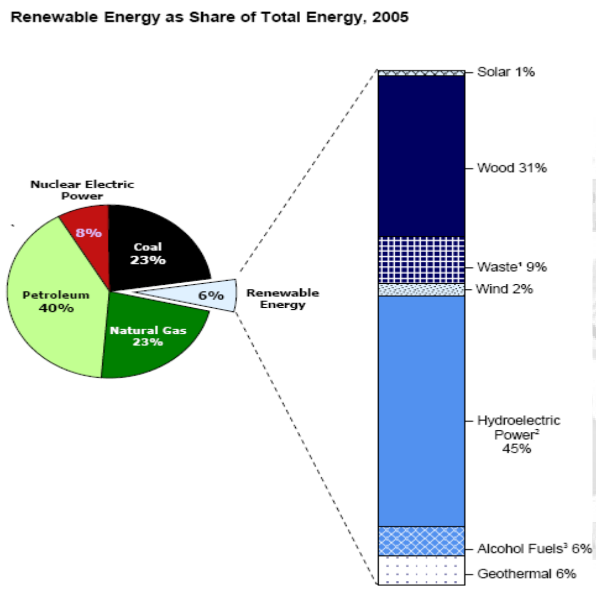


Figure 7: Renewable Energy Share

Hydropower is the most mature and reliable renewable energy source. It consists of a few large and numerous smaller dams producing 46% of the total renewable energy in the US. This configuration generates over 265 billion kilowatt hours of electricity (*Renewable, Alternative & Hydrogen Energy Industry Trends 2006).* Cost and reliability make hydropower attractive to consumers, but finite resources restrict future growth.

Biomass energy includes the burning of products such as wood, methanol, sludge, railroad ties, and agricultural waste, to produce heat, steam and energy. Recent political will elevated the development of biomass fuels to the top of the President's political agenda. In his 2007 State of the Union Address, President Bush set an ambitious goal for the nation to draw 20% of its energy needs from the use of ethanol, a biomass derived fuel compound. While this is a notable goal for improving U.S. energy self reliance, critics argue that biomass technology is not a productive return on investment of energy. This topic will be further addressed in the follow-on highlight essay, *National Security and Environmental Responsibility, Cellulose Ethanol in the Spot Light*.

Geothermal energy is generated from the earth's natural convective movement of internal gradients nearly 6,500 meters deep within the core of the earth's terrestrial crust, these geological heat reservoirs can be leveraged to produce steam and electricity (Geothermal Education Office, 2007). Geothermal energy is reliable and cost effective and the United States is already the greatest consumer of geothermal generated electricity. In 1999 the United States produced 2,840 Megawatts of geothermal electricity (Geothermal Energy Facts, 2007). Unfortunately, the natural recurring environmental phenomenon that creates geothermal energy is not widespread and therefore limit its use.

Solar-based power initially had its beginnings in the U.S. space program when it was used to provide power to satellites of the late 1950s. The subsequent development of crystalline silicon photovoltaic (PV) solar cells in the mid 1970s led President Carter to suggest, as part of his administration's energy policy, that solar power could be used in 2.5 million homes (Carter, 1977). Despite Carter's efforts to kick start the solar energy market with $800 million in funding and a 40% residential tax credit, it was shortly put on life support when he departed the office (Sklar, 1990). Thirty years later, the combination of the fear of green house gas (GHG) leading to global climate change, increased competitiveness in the utility market, increased electricity demands, and rising natural gas prices have helped to breathe a second life into the solar energy market.

Currently, solar energy accounts for less than one percent of the nation's total energy use. Even so, the market continues to increase at more than 25% globally and over 30% nationally. In the United States, photovoltaic capacity exceeds 400 mega-watts, small by comparison to other energy providers, but enough to power 240,000 homes annually (GAO 2006, p.29). Despite its 30 years of existence, solar energy has not evolved into a mature industry in the United States as it is yet to become cost efficient and base load dependable. However, significant developments are being worked to improve the photovoltaic efficiencies (Renewable, Alternative & Hydrogen Energy Industry Trends 2006). While solar power will likely never be a predominant player in the U.S. energy market, further technology development, prompted by government incentives, could turn it into an important part of the nation's energy portfolio.

Wind is a renewable energy source touted by many as a panacea to the nation's energy and environmental challenges. Although wind energy provides some capability it is not without its drawbacks, the most important of which is the ability to generate enough reliable power to meet consumer demands. In 2006, the U.S. net generation of electricity was a total 3,899.8 Million MWH (MMWH) of electric power. Of that, wind power generation was less than one percent (0.66%) (EIA MER, 2007, p. 100). In 2006, the United States had about 11,603 MW of installed wind generation capacity (AWEA, 2007). The average wind effectiveness between the installed annual capacity and actual production was about 25.4%. The current capacity equates to about 5,800 land-based wind towers at a typical size generator of 2 MW each (AWEA Ranking, 2006). Based upon these numbers, a quick calculation reveals that efforts to scale up to 20% electric generation from wind at the current 25% wind effectiveness would require about 175,800 wind towers to produce 780 MMWH annually.

This generation problem is due, in part, to the fact that wind tends to blow at inopportune times. The greatest production capacity is at night or during the early morning hours when demand is low and winds tend to decrease during the hotter mid day. The current technological limits of storing wind generated power impede the effective use of wind as a long term large scale renewable energy source.

While not fitting precisely into the definition of a renewable energy resource, conservation and efficiency should be key ingredients in any long term strategic national energy policy. The "negawatt" term, coined by many representatives from the energy industry, refers to energy saved through using less energy to complete a task or creating efficiencies through more judicious energy saving methods. Technological advances in insulation, transmission and dissemination are examples of negawatt savings. Industry representatives from Pacific Gas and Electric in San Francisco, CA, illustrated this point with their explanation of the evolution of the modern refrigerator. Today's refrigerator models use appreciably less energy and yet cost a fraction of the price of the 1960s models. This efficiency was achieved through government establishing efficiency standards, but then allowing industry to determine how best to achieve that goal. Taken collectively, these kinds of efficiencies can result in huge savings, and, according to energy experts, are the quickest immediate path to essentially increasing energy supply through demand reduction. Like the use of renewables, across the board application of conservation and efficiencies like the negawatt will form a more energy independent America.

As the use of fossil fuels becomes more contentious, a natural alternative is to turn to renewable resources. When the Energy Industry Study Team visited France, the team learned that France has engaged in a more aggressive look at biofuels, in particular biodiesel. France's decision to pursue nuclear energy in the 1970s has minimized its pursuit of renewables such as wind, solar and hydro. Conversely, the UAE has traditionally relied on fossil fuels. Today, the UAE looks at renewable energy resources as complementary to fossil fuels. For example, the UAE is pursuing the MASDAR initiative, which is a progressive community design concept, aimed at utilizing renewable energy resources to ensure no carbon and no waste emissions.

In comparison, the United States has engaged in a policy of energy independence, or breaking the "oil addiction." This policy has led to a strategy to promote renewables, primarily to ensure security of energy supply. Of course, President Bush's energy goals set out in the 2007 State of the Union Address, will require technological innovations or breakthroughs.

3. Recurring Themes

The EIST received presentations from a wide range of energy experts and interviewed energy industry personnel at several on-site visits, both domestically and abroad. During those sessions, the Team noticed some recurring themes, themes which may merit additional research because of their obvious tie to the energy industry and U.S. national security, but which are beyond the scope of this paper. These themes include:

- Lack of comprehensive U.S. energy policy. The lack of a consistent, strategically integrated energy policy impairs the nation's productivity and competitive edge.
- Impact of CO_2 emissions policy. Even though the United States did not adopt the Kyoto protocols, it seems likely the Congress will pass some form of CO_2 tax or cap and trade program. This environmentally focused legislation will have substantial impact upon the energy industry.
- Aging transmission and distribution infrastructure. Experts in nearly every sector of the energy industry highlighted a serious need to improve the energy distribution infrastructure, otherwise the system will be unable to meet future demand.
- Lack of human capital. Both domestically and abroad, industry experts observed the lack of qualified, trained personnel is already affecting the industry's ability to meet current labor requirements, both for skilled and unskilled labor.

4. Conclusions and Recommendations

In order to protect its interest, the United States should develop a cogent energy policy that is included in the National Security Strategy. That policy should:

- Focus the nation on creating and encouraging energy efficiencies.
- Diversify the U.S. energy portfolio, to ensure security of supply and price stability.
- Promote sustained, increased development of nuclear power, along with long-term waste disposal procedures and facilities.
- Create incentives aimed at transformative research, developing new, renewable environmentally-friendly energy sources.
- Accelerate available technologies for controlling greenhouse gas emissions that come from fossil fuels.
- Upgrade the U.S. transmission and distribution infrastructure to meet future demand.

This energy policy should be a prominent component of the 2006 National Security Strategy, as opposed to the current strategy document, where is instead a subset of the strategy related to economic development.

In conclusion, the five primary energy sources, petroleum, coal, natural gas and renewables are the life line of the United States. Americans demand superior energy capacity which is cleaner, cheaper, and more efficient to operate. Greater energy capacity equates to a higher standard of living, increased gross domestic product, and a flourishing economy. The world energy market is dominated by foreign owned oil and petroleum products and our reliance on the good will and economic interests of third world countries constitutes both market vulnerability, as well as a potential susceptibility to U.S. national security. Further, unintentional direct and indirect global market fluctuations could pose a risk to U.S. stability and economic preeminence.

ESSAYS:

NUCLEAR POWER AND THE ENVIRONMENT

The use of nuclear power as a substitute for coal or natural gas electricity generation eliminates the creation of carbon dioxide (CO_2) emissions that have been scientifically linked to global warming. Of all the environmental issues associated with nuclear power, the most formidable challenge is that of waste management. The average 1000-Megawatt electrical (MWe) nuclear reactor creates about twenty five tons of spent fuel per year. Currently, spent fuel is processed, treated, packaged, and stored in temporarily holding facilities located near the reactor.

The disposal portion of the waste management process represents one of the largest political challenges to the resurgence of nuclear power. Many of the radioactive elements in spent fuel have long half-lives. Nuclear waste contains plutonium-239 and 240. The half-life associated with these elements is 24,000 years, and 6,800 years (Radioactive Waste, p.3). This decomposition process translates into thousands of years of storage before the waste materials from the nuclear process no longer pose a threat to the environment.

The radioactive hazards, quantity, and time required for waste decomposition has prompted the U.S. government to look for a safer location to store nuclear waste. In 1982, Congress passed the Nuclear Waste Policy Act. This act charged the Department of Energy (DOE) with responsibility for finding a geological repository for nuclear waste disposal and prompted the scientific study of several candidate sites. From this analysis, DOE concluded that Yucca Mountain, located in Nevada, was the most suitable location. Since that time, the State of Nevada and other western states have fought the selection of Yucca Mountain, questioning the results of the scientific and geological studies and filing lawsuits against the federal government to slow the process and delay the project's implementation.

The future expansion of nuclear power within the United States depends on economics and environmental safety. Over the next 10 years, environmental safety of nuclear power can be improved by resolving the Yucca Mountain issue and reevaluating the government's waste management incentives. With respect to Yucca Mountain, the DOE anticipates submittal of their license application to the Nuclear Regulatory commission (NRC) in 2008 and expects the facility to receive its first shipment of nuclear waste by 2017. Finally, governmental implementation of economic incentives for nuclear waste generation could diminish the environmental concerns associated with spent fuel. The tenth of a cent per kilowatt-hour generated currently paid to the government for waste management services requires revision to target waste production rather then electricity generation. Increasing the cost of waste byproducts will provide incentives to waste generators to invest in technologies that reduce spent fuel.

National Security Benefits of Nuclear Power

Nuclear power continues to have a direct and important impact on national defense. The U.S. Navy's (USN) first nuclear submarine (the Nautilus) was launched in 1954. For the past two decades, the USN submarine fleet has been all-nuclear powered, as are the Nimitz-class aircraft carriers. The USN has been using nuclear propulsion for submarines and ships for decades without any accidents or fatalities. The environmental concern with USN subs and ships is the storage of reactor components and spent fuel. The USN spends approximately $10.2-$12.8 million to bury each decommissioned submarine's reactor components and $40 million for each cruiser reactor compartment (Federation, 2000). Storage of nuclear waste is a concern for the Navy as well as nuclear power plant owners.

If terrorists want to obtain nuclear material to make bombs, they may want to think long and hard before attempting to get waste from nuclear power plants and waste disposal sites. Nuclear facilities are some of the most heavily armed sites in the United States. Power plant and waste sites are kept secure by physical barriers, armed guards, locked and alarmed doors, key-card readers and continuous video surveillance (Nuclear Energy Institute [NEI], 2007). Illustrative of the emphasis placed upon security is the fact that the majority of all personnel who work at nuclear power plants are employed in security-related positions.

As the United States tries to reduce dependence on foreign oil, reliance on nuclear power should be increased. Currently, 83% of the uranium needed for fuel in U.S. nuclear power plants is imported from other countries. Of this 83%, 60% comes from Australia and Canada. Given the close relationship the United States has had with these two countries, it is unlikely that they would curtail our uranium supply (Energy Information Administration [EIA], 2006). There are six fuel fabrication facilities in the United States. Even though these are not all owned by U.S. companies, their location within the United States makes them assets for our country (Nuclear

Regulatory Commission [NRC], 2006). If, for some reason, the owners of these companies decided to shut down these facilities, the U.S. government has the authority to take them over if deemed necessary for national security. In addition, as interest in nuclear power plants increases, investments will increase which will allow more facilities to be built within the United States.

By adding more power to the electric power grid, brown-outs can be reduced, if not eliminated. If brownouts begin occurring in Washington D.C. or New York City it could have catastrophic consequences since these two cities are vital to our economic and national security.

By increasing nuclear power generation within the United States, less natural gas will be needed and therefore less will need to be imported. This reduces our dependence on foreign nations for our electricity needs.

Policy Initiatives Promoting Nuclear Power

Policy changes initiated during the last few years have laid the foundation for resurgence in nuclear power. The National Energy Policy (NEP) of 2001 established a framework for expanding nuclear energy use by simplifying licensing of new plants and extending licenses on existing plants, encouraging the design and development of next generation reactor designs, and promoting research and development into advanced nuclear fuel cycles which are more efficient and reduce long-lived fission byproducts. The NEP led to the establishment of three significant programs to expand nuclear power generation.

- The Nuclear Power 2010 program, established in February 2002, which encouraged construction of new nuclear plants. It represents a joint government/business effort to identify sites for new reactors, identify weaknesses in obtaining licenses and develop new nuclear plant technologies.
- The Generation IV program aimed at developing reactor designs that would be safer, more economical and better protected against the possibility of nuclear material proliferation. Some Generation IV designs include features which would allow reactors to also produce hydrogen as a byproduct. Other designs propose smaller, self-contained, modular reactors which could operate in clusters.
- The Advanced Fuel Cycle Initiative (AFCI) which would investigate processes to refine and recycle nuclear waste material thereby reducing the amount of fresh nuclear fuels needed in the nation's reactors.

The Energy Policy Act of 2005 (EPACT 2005) provides significant incentives for new commercial reactors. These include tax credits, loan guarantees, insurance against regulatory delays, and extensions in the nuclear liability system. Several utilities have announced they will seek licenses for up to 30 new reactors. Although no commitments have been made to build the reactors, nuclear industry officials predict that incentives in EPACT 2005 will lead to the first new U.S. reactor orders since 1978.

Emerging Capabilities

The nuclear power industry is designing with construction in mind. For example, Westinghouse is aiming for a 36-month construction schedule for its flagship AP1000 reactor, from concrete to fuel load. The average capacity of these new designs reactors is also larger than their predecessors. Earlier reactor designs were in the 700-1100 Mwe range whereas newer designs range from 1100-1600 Mwe. Construction costs for new reactors completed since the mid-1980s ranged from $2 to $6 billion. The industry predicts that new plant designs could be built for less than half that amount if many identical plants were built in a series. Foreign countries looked past the nuclear incidents at Three Mile Island and Chernobyl and have been building reactors for decades while the United States has stood still. The current proposed designs for the United States are already operating abroad and have proven track records.

Fusion energy has long been promised as a cheap, clean and abundant source of power which would someday replace nuclear and other sources of electrical power such as coal and natural gas. Fusion energy refers to the combining of light hydrogen nuclei (tritium and deuterium) to release large amounts of energy, helium gas and high energy neutrons. Both tritium and deuterium are readily available in nature. Helium is an inert gas. Fusion energy would eliminate the need for long term waste disposal, provide zero emissions of greenhouse gases and the high energy neutrons it produces (in contrast to low energy neutrons in fission), and could be used to 'burn' current stockpiles of long-lived radioactive waste. Initiating the fusion reaction requires subjecting the tritium and deuterium to temperatures on the order of 100 million degrees Celsius. Controlling and sustaining the resultant plasma from such a reaction is a major obstacle in deploying the technology. However, fusion reactors are envisioned to provide 10-25 times as much energy as is used to initiate the fusion reaction.

The most recent effort to make fusion energy viable is the International Thermonuclear Experimental Reactor (ITER) in Cadarache, France. ITER is a $10B effort over ten years funded by the U.S., Japan, China, EU, Russia, India and South Korea and began construction in 2006 (White Hot, 2006). Its goal is achieve 500 MW of fusion energy and sustain it for 400 seconds. If successful, fusion energy reactors could one day be built on existing sites currently hosting fission reactors and could make use of existing infrastructure such as access to power grids and sources of water.

Skepticism aside, the success of nuclear power abroad will probably lead to the success (again) of nuclear power in the United States. Technology has provided substantial improvements and efficiencies which must now be exploited through policy execution. The tolerance for energy shortages is low among the general public and nuclear power provides a proven method for delivering energy on a very large scale which alternative energy sources such as solar, wind and geothermal can not. Alternative energy sources may have niche applications but, our nation's energy needs are large and therefore our solutions must deliver large results. Nuclear power can deliver the large scale results that the public is demanding.

-By Feza Koprucu, Alan Smith, Terry McDaniel

CELLULOSIC ETHANOL IN THE SPOTLIGHT

What are biofuels and how did they come to be in the national spotlight? Biofuels are organic compounds that come from many feed sources such as corn, beets or sugar cane for ethanol, soybeans for biodiesel, and wood chips, switch-grass, human waste or refuge for cellulosic ethanol (CE). President Bush brought nationwide attention to CE and switch grass in his January 2007 State of the Union address. This essay will review the biofuels and CE market, will discuss the type of markets, and will look at how various businesses compete against each other, and more importantly against the fossil fuel market. Additionally, this paper will investigate the major criticism often leveled at biofuels, "is the public interest served by the correct allocation of resources, where marginal cost equals marginal revenue (Losman, 2007) and justifies investment in biofuels, specifically CE?" Are biofuels really worth it?

Biofuels By the Numbers

In the last few years, the environment and national security spawned a biofuels market. Biofuels and CE are goods and services markets, where businesses supply goods and services for sales revenue (Gwartney, 2006). Ethanol is a global market, where buyers and sellers come together to trade, with the United States and Brazil supplying 70% of the goods (Baker, 2007).

A gallon of ethanol supplies approximately 70% of the energy that one gallon of gasoline provides (Tilman & Hill, 25 Mar 2007). The United States consumes about 140 billion gallons of gasoline each year (Scott & Bryner, 2006), equivalent in energy to 200 billion gallons of ethanol, which, to produce, would require corn crops double the land mass of Alaska (derived data from Tilman & Hill, 25 Mar 2007). We now have approximately 140 corn ethanol plants in the United States which annually produce five billion gallons of corn ethanol (Stanford University, 2007).

Biodiesel is successful in Europe, where Archer Daniels Midland VP of Europe and Asia, Mark Zenuk, observed that "the market growth in the biodiesel sector has been nothing short of explosive" (International News, 2007). Biofuels in general have not reached full capacity and Zenuk predicts the biodiesel global market will increase 350% over the next five years. Archer Daniels Midland is the top producer of biodiesel, more popular in Europe, and the number one U.S. producer of ethanol.

The CE market is in its infancy, with the first U.S. commercial scale CE plant projected for opening in 2009. Financial risk is reduced by joint ventures, like Broin Industries and Dupont on the first U.S. CE plant, which is sponsored by a $200 million subsidy from the federal government (Scott & Bryner, 2006). A new CE enzyme technology, using cornstalks and leaves, will increase ethanol production by 11% for a bushel of corn and 27% for an acre of corn (Scott & Bryner, 2006). Combine the other ethanol plants, with the 79 being built (Renewable Fuels Association, 2007), to the 105 operational biodiesel plants, with 77 more biodiesel plants (National Biodiesel Board, 2007) under construction, and you have intense biofuel market growth and competition.

Market Impact

Biofuels are not economically competitive until crude oil prices reached about $60 per barrel, at which point biofuels compete at $2.60 per gallon (Science Daily, 2006). Without the 51 cent per gallon subsidy, ethanol will not be economically viable. While the current ethanol market is 5 billion gallons compared to the 140 billion gallons of gasoline used annually in the United States, roughly 3-5% by volume (Science Daily, 2007), (Scott & Bryner, 2006), the biofuel market for transportation is still immature. Carnegie Mellon just reduced corn ethanol production costs by 11% (Science Daily, 27 Jan 2007). And more CE production facilities, technological advances, and increased learning curves could drive unsubsidized ethanol to compete with gasoline.

The barriers to CE market are high capital outlays and asymmetric information, which have led to a comparative advantage for established energy companies. Commercialization driven by innovation requires huge outlays and the U.S. government can mitigate investor risk with research, development, and production subsidies, as long as subsidies are limited in time and scope, and performance-based, which could prevent shirking and free riders (Losman, 2007).

No market happens in a vacuum; ethanol is no exception, with some positive and negative spillovers, which should be dealt with respectively by subsidies and taxes (Losman, 2007). Edible corn prices rose in 2006 from $1.86, to peak at $4 per bushel in January 2007, and edible corn continues to compete with other corn users. One externality of rising corn prices is the rising price of tortillas and other corn products and for feed for chicken and beef (it takes 7-8 pounds of feed corn to raise a pound of beef). As CE feed corn prices rise, farmers grow more feed corn, rather than sweet corn for food. This has an unexpected externality of dropping edible corn supplies and raising both edible sweet and feed corn prices, which are seemingly non-competitive markets.

Another externality to factor into the biofuel market is the delivery mechanism for ethanol or CE once large scale quantities start to be produced. Ethanol and CE can not use the 100,000 miles of regular gas pipeline, because the left over gasoline residue and impurities would adversely mix with ethanol (Science Daily, 5 May 2006). Transportation would be over the road or rail and this would negatively impact biofuel's competitiveness with fossil fuels.

Matt Crenson, AP writer, argues that national resources for ethanol production are an even energy proposition when you factor in all energy input from seed to pump. A perfect free market for transportation fuel, with no incentives, would drive CE supply and demand to an equilibrium price that competes with fossil fuels. Mr. Crenson declares the ethanol market, created by cheap corn and high oil prices, benefits CE, and yields 4-6 times higher than corn ethanol. DoE estimates one billion tons of CE feed stock could produce 30% of US oil needs (Crenson, 2006).

Farming: Backbone of the CE Market

Farming is the core of biofuels, which increases competition for fertile farmland. Conservation Reserve Program (CRP) has 37 million acres of marginal, less fertile farms and land on road edges or old farmland (CRP, 2007). Here, perennials are better than annuals, because they save resources and require planting only once every 10 years. Biotechnology will also help maximize plant density, minimize water requirements, reduce insecticide, herbicide and fertilizer requirements and maximize harvest efficiency while minimizing transportation costs. Richard Hamilton, President of Ceres Inc., sees biotechnology improving yields, reducing soil erosion, decreasing pesticide use, and developing drought, heat, and cold resistant plants for different soil conditions (Hamilton, no date). In 1998, Iowa State University found an acre could produce 4-5 tons of switch grass (Iowa State University, 1998), while Auburn University in 2006, produced a 250% increase in per acre output of switch-grass (Bio-fuel Review, 2006). Diverse prairie grass yields were 238% higher than single grass species (Science magazine, Dec 2006) and required less weed killer, pesticides and fertilizers (Tilman & Hill, 2006). Some grasses are less dense (results in easier harvesting) and require 50% less water than alfalfa or spinach crops (Science Daily, Mar 2007).

Switch-grass is one of the most promising prairie grasses for biofuels. Auburn University (Biofuel Review, 2006) found an acre produced 11.5 tons of grass, yielding 1,150 gallons of ethanol, a 300% increase from corn ethanol, and a 15-20 times net energy output when energy use for transport, tractors, and fertilizers are included. Switch-grass is a drought-resistant perennial grown wild on marginal land, and except for the roots, the entire plant is harvested. CE's advantage as a superior feed stock is that corn only uses kernels as a feed source, and CE feed stocks are easier to manage and do not compete with corn or beets as a food source (Bio-fuel Review, 2006). High energy efficient CE feedstocks reduce land required to supply 200 billion gallons of ethanol to a region slightly larger than Texas, approximately 270,000 square miles. President Bush's goal of 35 billion gallons of ethanol by 2017 only requires land the size of New York State for CE feedstocks.

The wood pulp mill industry is similar to the biofuel industry, also turning organic material into a product. A by-product of the pulp process is hemi-cellulose; which Agenda 2020 Technology Alliance argues can be used to produce ethanol and estimates an average pulp mill would cost $33 million and would annually produce 19 million gallons of ethanol and 6 million gallons of acetic acid (a profitable byproduct). According to Agenda 2020, the "operating cost is near $.35 per gallon with yearly net revenues of $33 million," essentially returning installation costs in just one year. The DoE has funded Agenda 2020 with $1.7 million, to go along with Agenda 2020's venture partners' individual investments of $1 million (Boswell, 2007).

National Biofuels Policy—"The Perfect Storm" and Beyond

The United States has subsidized ethanol for years, and continues today with a $.51 per gallon tax exemption. While subsidies make sense for fledgling industries, at some point, the market must stand on its own by relying only upon competition to survive. As Brent Erickson, executive vice-president at Biotechnology Industry Organization, said, "the high price of petroleum, government incentives to reduce dependence on imported oil, and growing efforts to address climate change have created a perfect storm for bio-based products" (Targeted News Service, 21 Nov 2006). The U.S. incentives will continue as long as representatives from the Corn Belt remain united, the crude oil price remains high and a carbon tax still hangs in the air, all of which makes biofuels more attractive than fossil fuels.

In summary, commercial development must continue in ethanol, without subsidies. On the other hand, considering CE's significant output and production efficiencies, incentives for CE, such as loan guarantees for R & D or production, should immediately increase. The government must prevent subsidies or incentives from becoming a timeless expectation, and should allow the market to eventually survive as a "free market." Additionally, fast-track approval of dedicated CE crops and carbon credits should begin to help level the playing field with row crops and fossil fuels. Pure competition, not open-ended incentives, will eventually drive innovation and technology, and lead toward Winston Churchill's statement, 'energy security is achieved through diversity.'

- By Kevin Leek

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