ENERGY

ABSTRACT. Energy is vital to our economy and way of life. U.S. energy consumption exceeds domestic supplies, which is a major factor in our national security strategy. Our future need for energy imports will become even more acute as our economy grows and domestic resources decline. Present sources of energy raise concerns over global warming, air and water pollution, and the environmental impacts of resource extraction. The critical role of energy in U.S. society demands a comprehensive, integrated energy policy. Defining such a policy will be a difficult, contentious undertaking, because there are many tough issues where the opposing arguments are sound and strongly advocated. Some of these issues will be resolved by finding "win-win" solutions that please all parties, but more likely, the final form of our policy will reflect bargaining and compromise. Informed by our visits with energy experts in Houston and Australia, this paper overviews each of the major sectors of the energy industry: oil, natural gas, coal, electricity, nuclear power, and renewables. Five short essays discuss key energy challenges: developing a national energy policy, protecting the environment, promoting the research and development of new energy technology, securing our energy infrastructure, and determining a path for electric restructuring. In each area, policy recommendations are presented, as developed by the Energy Industry Study of the 2002 Class of the Industrial College of the Armed Forces. These recommendations represent the culmination of months of study, candid discussions with leaders in government and industry, and on-site assessments of the industry, both domestically and abroad.

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Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
2002	**N/A**	**-**

4. TITLE AND SUBTITLE **2002 Industry Studies: Energy**	5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **The Industrial College of the Armed Forces National Defense University Fort McNair Washington, DC 20319-5062**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S) 11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**UU**	**31**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

PLACES VISITED

Domestic

BP Solar, Frederick, MD.
BP, Houston, TX.
CONSOL Energy, Blacksville No. 2 Mine, Morgantown, WV.
Dickerson Generating Plant, Mirant Corporation, Dickerson, MD.
Entergy-Koch Trading, Houston, TX.
ExxonMobil Friendswood Oil Field, Houston, TX.
ExxonMobil Katy Gas Plant, Houston, TX.
Green Mountain Wind Farm, Garrett, PA.
Halliburton Energy Services, Houston, TX.
Houston Ship Channel, Houston, TX.
Landmark, Houston, TX.
Magic Earth, Houston, TX.
Montgomery County Resource Recovery Facility, Covanta Energy, Dickerson, MD.
Offshore Drilling Rig Museum, Galveston, TX.
Reliant Energy, Houston, TX.
Shell Deer Park Refinery, Deer Park, TX.
Shell US, Houston, TX.
U.S. Department of Energy, Washington, DC.
U.S. Coast Guard, Houston Ship Channel operations, Houston, TX.

International

Australia Bureau of Agricultural & Resource Economics, Canberra, Australia.
Australia Gas Light Company, Sydney, Australia.
Australian Gas Association, Canberra, Australia.
Australian Petroleum Production & Exploration Association, Canberra, Australia.
BP Australia, Melbourne, Australia.
BP Solar, Sydney, Australia.
Energy Market Review Secretariat, Canberra, Australia.
Energy Research, Development, and Information Center, University of New South Wales, Sydney, Australia.
Minerals Council of Australia, Canberra, Australia.
National Electricity Market Management Company, Melbourne, Australia.
Northern Territories Office of Territory Development, Darwin, Australia.
Phillips Petroleum Australia, Darwin, Australia.
Rio Tinto, Melbourne, Australia.
U.S. Consulate, Sydney, Australia (ExxonMobil on PNG Gas Project).
U.S. Embassy, Canberra, Australia.
Warkworth Mine, Rio Tinto, Singleton, Australia.
Woodside Energy Ltd., Darwin, Australia.

Introduction. America uses more energy than any other nation on earth. Energy is vital to our economy and way of life. U.S. energy consumption exceeds domestic supply, which is a major factor in our national security strategy, particularly in relation to the volatile regions of the Middle East and Persian Gulf. Our future need for energy imports will become even more acute as our economy grows and domestic supplies decline. Present sources of energy raise concerns over global warming, air and water pollution, and the environmental impacts of resource extraction. These compelling issues are at the forefront of American politics. As of this writing, competing versions of a national energy policy have been passed by the Senate and the House of Representatives. The Bush administration clearly staked out its own position when it published the report of the National Energy Policy Development Group in May, 2001. Resolving the differences in these plans is a critical national challenge to the development of a comprehensive national energy policy. Informed by our visits with energy experts in Houston and Australia, this paper will overview each of the major sectors of the energy industry: oil, natural gas, coal, electricity, nuclear power, and renewables. Next, five short essays discuss key U.S. energy challenges: developing a national energy policy, protecting the environment, promoting the research and development (R&D) of new energy technology, securing our energy infrastructure, and determining a path for electric restructuring. In each area, policy recommendations are presented, as developed by the Energy Industry Study of the 2002 Class of the Industrial College of the Armed Forces. These recommendations represent the culmination of months of study, candid discussions with leaders in government and industry, and on-site assessments of the industry, both domestically and abroad. It is our hope that the analysis and proposals presented will contribute to the national debate on these issues.

Energy and the American Economy. The American economy remains the largest and most diverse in the world. Although there has been a substantial shift from manufacturing to services, abundant, reliable energy is critical. In 2000, energy accounted for about 7% of total U.S. Gross Domestic Product (GDP).[1] As shown in Figure 1, this percentage is down from the early 1980's, but the effect of energy price spikes can still have a significant economic impact. These price spikes have in fact been direct contributors to three of the nation's last four recessions.

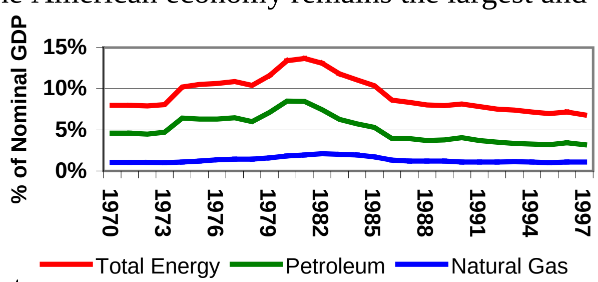

Fig 1. Energy Share of U.S. Economy
Source: Energy Information Agency, DOE

Americans consumed 99.3 quadrillion British thermal units (Btus) in 2000. By contrast, all of Western Europe used 66 quadrillion Btus. While Americans use more energy, we are relatively efficient consumers. When measured against GDP, U.S. energy intensity, that is, Btus per dollar of GDP, has fallen 42% since 1973, from 19,000 Btus per dollar of GDP to approximately 10,700 Btus per dollar of GDP.[2] A combination of technology, conservation, and a less energy-intensive economy (less heavy industry, more services) has contributed to this decline. Over the next 18 years, the Department of Energy (DOE) forecasts that the U.S. economy should grow at an average annual rate of 3%, to $17.03 trillion (1997 dollars). Over this same period, DOE projects that U.S. energy use will rise to approximately 130.9 quadrillion

Btus while our energy intensity is expected to continue its downward trend to approximately 8,000 BTUs per dollar of GDP.[3]

Over this same time, the amount of energy we import will continue to increase. Today, we import approximately 27% of our energy needs; by 2020 we will import 31%.[4] Future supply disruptions could seriously impact the U.S. economy. Hence, maintaining international stability will become increasingly important to our national security.

Upstream Oil. Crude oil is the nation's largest source of primary energy, serving almost 40% of U.S. energy needs. In 2000, the U.S. consumed approximately 19.5 million barrels per day (mbd). DOE estimates that U.S. oil consumption will grow to a total of over 26 mbd by 2020. Almost 66% of oil consumption is in the form of transportation fuels. Approximately 24% of oil consumption is in the industrial sector, while the remaining 10% is consumed in residential and commercial heating.[5] There is a growing shortfall in domestic supply. Domestic crude oil production peaked in 1970 at 11.7 mbd and has slowly declined to 9.1 mbd in 2000. Although the U.S. has over 21.8 billion barrels of proven domestic reserves (recoverable from known reservoirs under existing technology and price conditions), we are becoming increasingly dependent on imported oil. From 1973 to 2000, oil imports rose from 35% to 52% of domestic consumption, when imports reached 11.5 mbd. The Persian Gulf provides approximately 30% of our oil consumption, 18% from Saudi Arabia, 9% from Iraq, 3% from Kuwait. The remaining oil imports come primarily from Mexico, Canada, and Venezuela. Increasing demand for petroleum is projected to raise the share of demand met by net imports to nearly 65% in 2020.[6] In contrast to the U.S., Australia is presently nearly self-sufficient in oil. Most experts, however, expect Australia to become a net oil importer in the years ahead, although by no means as dependent on world markets as the U.S.

Price. Trends over the past several decades show that world oil prices are very volatile. Market forces and the economics of supply and demand can best explain the dramatic swings in the price of oil. After the September 11 terrorist attacks and a global recession, oil prices plummeted as air and road travel declined and supply was plentiful. Crude oil futures on the New York Mercantile Exchange recently reached a 27-month low falling to $19.74 per barrel, and then stabilized at around $22 per barrel. This price is nearly 30% lower than the price on September 10 of $27.66 per barrel. In 2020, DOE projects oil prices at $24.68 per barrel. This slight increase is due largely to an anticipated higher world oil demand and the improvements in the effectiveness of OPEC in managing oil production.[7]

Challenges. Given the paucity of domestic oil resources and growing demand, the U.S. will remain dependent on foreign suppliers. This dependence has raised concerns regarding the nation's energy security. Past policies have relied on market forces to provide stable and predictable energy prices, which are essential to sustaining our economy and safeguarding our security. However, relying on market solutions increases risk, because of price volatility and supply uncertainty. U.S. energy policies must be keyed to ensuring uninterrupted supply at stable prices.

Recommendations. A comprehensive strategic approach to ensure our crude oil security is essential, one that makes the distinction between dependency and vulnerability. Dependence on foreign sources does not necessarily imply that the U.S. is vulnerable to oil disruption and price volatility. Diverse global suppliers enhance energy security. To the extent that we encourage production in the Americas, Russia, and the former Soviet Republics, the ability of other nations, particularly those in the Middle East, to disrupt supply and increase prices is reduced. Additionally, maintaining our Strategic Petroleum Reserve, and increasing domestic production are important components of our energy security. Policies to increase domestic production invariably come into conflict with environmental interests. However, restrictions on domestic drilling and exploration for environmental reasons must be carefully assessed against their effect on our economy and security. Clearly, a balance is necessary and achieving an appropriate balance will remain a difficult task for U.S. policymakers.

Downstream Oil. The downstream portion of the oil industry, which includes refining, transportation, and marketing, is key to unlocking petroleum's full value. Petroleum refineries convert petroleum from its natural state to a range of commercial products. About 90% of petroleum products are fuels such as gasoline, aviation fuel, distillate and residual oil (diesel oil, heating oils, and industrial oils), liquefied petroleum gas (LPG), coke, and kerosene. The remaining 10% goes to non-fuel products such as ethylene, propylene, and benzene, used in the manufacturing of chemicals, plastics, synthetic rubber, synthetic fibers, drugs, and detergents.

The refining industry is characterized by low product margins, low profitability, and substantial restructuring. The cost of environmental compliance has grown substantially with the passage of the Clean Air Act Amendments of 1990 (CAAA90) and has had a major impact on the profitability of domestic refineries. This legislation required a phased reduction in vehicle emissions of regulated pollutants. In response, refineries developed reformulated gasolines that reduced pollutants. Compliance with air quality regulations will continue to be a major factor affecting domestic refinery investment. During the period 1990 to 1997, major integrated firms were successful at improving profitability by reducing their operating costs by 6%, marketing costs by 28%, and energy consumption by 24%. Downstream mergers, alliances and joint ventures also contributed to increased margins. In response to rising demand, U.S. refineries have improved the average annual refinery utilization rate from 69% in 1981 to 95% in 1997. Recent refining investment has focused on meeting the environmental requirements of the CAAA90.

Bringing petroleum products to market is a huge undertaking in both the U.S. and Australia. In the former, four major transportation modes, water, road, rail, and pipelines, form a system that distributes refined products to final consumers. Distance, geography, technology, and economics all play a role in shaping the transportation network. Storage structures are located along transportation routes to accommodate the capacities of different transportation modes. In Australia, the challenges are even more acute, as the country imports fuels from Singapore to meet air quality standards, while shipping products from its few western and southeast refineries to populations scattered throughout the continent and nearby islands.

The marketing sector of the downstream petroleum industry is responsible for sales to retailers and some final customers. Refineries may sell directly to end-users, but most often the consumer buys from a retailer. Refined petroleum products are sold to a variety of users in the transportation, residential, industrial, commercial, and electric utility sector of the economy.

Recommendations. (1) Boutique fuels. Different regions of the country have different fuel production standards. These so-called boutique fuels are intended to have positive benefits on air quality. However, they make it difficult for the U.S. to get the maximum value out of its refining capacity, because of the great variety of "recipes" required for gasoline, depending on its ultimate destination. The U.S. Environmental Protection Agency (EPA) should review the contradictory fuel requirements with a goal of standardizing them. (2) Security. The downstream energy infrastructure was created in an open society where the threat of terrorism was unanticipated. Refineries and storage facilities are often located close to major transportation centers, including interstate highways, and ports. Their vulnerability is significant. National leaders should direct an assessment of vulnerability of these facilities, and identify measures to mitigate risks.

Natural Gas. The U.S. is the world's greatest user of natural gas, consuming 27% of total annual worldwide production, 22.7 Trillion cubic feet (Tcf) in 2000. The industrial and residential sectors favor gas as a heating and cooking source and are the largest sources of consumption.[8] American consumers reacted to the oil shortages and price spikes of the 1970s and 1980s by converting to natural gas for home heating. Today, 53% of U.S. homes are heated by gas. Electrical power generation is another sector of gas usage on the rise, currently meeting 16% of the nation's total electrical energy needs.[9] The U.S. has proven natural gas reserves of 167 Tcf, or 3.2% of the world reserves. In 2000, the U.S. produced 19.1 Tcf representing 22% of the world's natural gas production.[10] The U.S. ranks second to Russia in gas production by only a narrow margin. Top U.S. gas producing states (in descending order) include Texas, Louisiana, Oklahoma, New Mexico, Wyoming, Colorado, Kansas, Alaska, California, and Alabama.[11]

Import/Export. The U.S. imported 3.6 Tcf of natural gas in 2000 or 16% of total consumption. Canada provided the majority of U.S. imports. The U.S. also imports gas from several other countries in the form of Liquefied Natural Gas (LNG). LNG has become more commercially viable because supplies have increased while extraction and transportation costs have decreased. Regasification of LNG is a growing industry. The current import potential for LNG is estimated by DOE at 2 Billion cubic feet (Bcf) per day. [12] LNG already services a major portion of demand in New England. While the U.S. may be supply constrained in natural gas production, Australia is in fact demand constrained, with vast gas reserves and a relatively small population. As a result, the country is making major efforts to expand its gas exports to the U.S. and elsewhere.

Distribution. The gas storage and distribution system in the United States is extensive. However, even after a decade of huge growth, it is barely able to satisfy the current demands of the industry. The transmission network for wholesale gas includes more than 270,000 miles of pipeline. The distribution network to final customers is made up of 925,000 miles of connecting pipeline. Storage capacity is at about 3.2 Tcf.[13] Regulatory reform has reshaped the natural gas pipeline industry by creating increased competition. At the same time, gas supply sources have diversified and end-use markets have expanded. In order to keep up with the projected growth in demand, pipeline companies have proposed new projects which would add 12 Bcf of capacity, representing a 10-12% increase in transmission capacity.[14]

Demand. As the U.S. economy grows and GDP increases, so will the demand for natural gas, a primary generation fuel for electricity. Gas is a relatively cheap, non-polluting source of energy. It will be the fuel of choice for new electric power plants for the foreseeable future. About 90% of the power-generation facilities under construction are gas-fired. The power industry expects to increase its annual gas demand by an average of 5.4% through 2020, more than double the 2.2% growth rate of gas consumption for the economy as a whole. New combined-cycle facilities equipped with more efficient natural gas turbines will help lower the cost of gas-fired electricity to levels competitive with coal-fired plants. As a result, annual gas usage in the U.S. may rise as high as 33 Tcf by 2020.[15]

Outlook. The gap between domestic production of natural gas and demand will continue to widen. Rising prices will induce domestic suppliers to increase production, but imports must also increase to fill the gap. Canada will supply the lion's share of U.S. imports. Imports from Mexico will also increase. The greatest change in supply will be the role of LNG. Based on proposed regasification projects, U.S. capacity could increase from the current 2 Bcf per day to 8 Bcf per day by 2010.[16] This represents as much as 9-10% of forecasted total annual consumption. California's demand for natural gas may be met in part by new LNG regasification facilities such as the one planned for Baja, California. Foreign countries, including Australia, are finalizing deals to increase LNG exports to the U.S. Even though California gas prices have subsided since the peaks in 2001, these suppliers are entering what promises to be a lucrative market. Developers of Australia's Timor Sea gas fields are already negotiating contracts to sell LNG directly to the Baja plant when it comes on line. Long-distance pipelines offer another means to expand supply. ExxonMobil developed the Sable Island-Maritimes gas pipeline that already has proven economical. The proposed Alaska pipeline is a riskier venture that would require a higher sustained price than currently forecast to be economical. Even if the project is approved now, the Alaska gas pipeline is not expected to provide delivery to the lower 48 states until approximately 2010.[17]

Recommendations. The Bush administration's proposed National Energy Policy seeks to promote greater energy self-sufficiency by removing impediments to exploration and development of new natural gas sources, including limited exploration in federal lands. It supports the use of new technology, including methods for extracting greater percentages of gas from existing wells and new imaging and offset drilling techniques. These developments will reduce the footprint of drilling operations and make extraction more environmentally friendly. The proposed energy policy also recognizes the need for increasing pipeline capability to keep up with increased production. Additionally, the plan will expedite the permitting and licensing of new pipeline projects. Cross border pipelines to Canada and Mexico will also be supported to improve access to the best sources of imported gas. Permitting for new LNG terminals will also be given a high priority. Each of these measures represents sound policy that will contribute measurably to a secure energy future.

Coal. Coal is the most abundant energy resource in both the U.S. and Australia, with estimated domestic reserves sufficient for the next 250 years and 800 years, respectively. In fact, U.S. coal supplies represent the single largest reserve of energy held by any nation in the world, equal in energy potential to the entire world reserve of oil.[18] Approximately 90% of coal is used to generate electricity, producing more than half of our electric power.[19] The remaining 10% is used in the production of steel. Coal is a desirable energy source because of its abundance and low, stable costs. However, these advantages are offset by relatively high emissions of pollutants, particularly sulfur dioxide and nitrogen oxide. Consequently, some people view coal as a dirty, less desirable form of energy. Similar discussions are taking place in Australia, as new domestic power plants will choose between exceedingly low-cost coal mined from huge surface mines, or cleaner natural gas. Australia is blessed, however, with relatively low-pollutant coals. As the world's largest coal exporter, it will continue to target export markets.

The U.S. coal industry earns $22 billion in revenues in 27 states.[20] Coal is mined principally in three areas, Appalachia, the Illinois basin, and Wyoming. Coal production is increasingly concentrated with the twenty largest firms now accounting for almost 70% of production.[21] Coal's primary competition in electricity generation comes from natural gas, which has become the preferred fuel for power generation. Nuclear power and renewable forms of energy are also competitors, but natural gas will likely continue to be coal's number one rival.

Recommendations. Overall, policies in the energy industry must be reasonable, rational, and pragmatic. In the coal industry, policies should encourage new electric power generation construction, support R&D to improve extraction technology, and reduce pollution. With this in mind, specific policy recommendations are as follows.

First, we must streamline siting procedures for new electric power generation to meet our increasing demand for electricity. Current siting procedures are far too time consuming and thus discourage investment. The procedures for constructing a coal-fired plant take roughly twice as long as those for natural gas. The Bush administration's National Energy Plan calls for construction of 1,900 new electricity plants to meet growing demand.[22] Cutting red tape for new construction is essential to foster a positive environment for investment.

Second, we must assist the electric power industry in developing clean coal technology. The government can either fund research in this area or offer tax incentives for R&D. A great deal of progress has already been made in reducing emissions from coal-fired power plants, but more work must be done. Thus far, coal producers have been able to meet emission requirements as dictated in the CAAA90. However, there is a strong possibility environmental interests will persuade elected officials to pass new legislation with even tougher air quality standards. Therefore, coal producers must continue to invest in technology to improve air quality. Industry analysts believe a goal of zero emissions from coal-fired generation is achievable by 2020.[23]

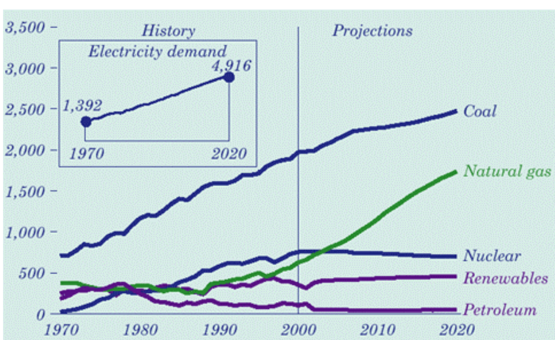

Figure 2. Electric generation by source 1970-2020
Source: Energy Information Administration, DOE.

America strives for both economic growth and a clean environment. Affordable energy is critically important for U.S. economic growth. The U.S. will continue to rely on coal because it is affordable and abundant. The greatest barrier to maximizing the benefits of this important resource is its effect on air quality, which must be addressed.

Electricity. For many years, the U.S. electric power industry was a fairly boring sector of the economy. The industry focused primarily on reliability and safety. Despite this low profile, electric power is vital to our economy. The recent growth in high technology and information technology industry has further increased the importance of abundant, low-cost, and reliable electric power. Recently, public interest has skyrocketed in the industry as a result of the controversy surrounding California's electric deregulation debacle, the collapse of Enron, concerns over global warming, and the increased terrorist threat to U.S. energy infrastructure. Clearly, the dominant long-term issue faced by the industry is how federal and state governments will pursue greater competition in the electric power industry. California's recent experience, where electricity prices peaked at $1,500 per megawatt hour in June 2000, undermined the expectation that restructuring would reduce prices.[24] As a consequence, a number of states have delayed implementation of their restructuring plans, although some states are proceeding with implementation.

The advent of restructuring has produced great turbulence among electric utilities. Ownership of generation has become increasingly concentrated. The ten largest generation firms now control 50% of U.S. capacity.[25] Firms are positioning themselves for future market growth, because demand is expected to grow sharply in the next twenty years. The U.S. will need 393 gigawatts of new generation capacity by 2020. This equates to building 1,900 generation plants over that time frame. Coal and natural gas are expected to account for the great majority of that growth, with shares of other forms of generation remaining relatively constant.[26]

Over the last several years, Australia has also been engaged in electricity market restructuring efforts. While the country's population patterns do not permit a truly national market, attempts have been made to increase competition in generation. Additionally, larger electricity customers are being provided meters that will record time-of-day use to support an hourly pricing scheme. Anxious to avoid the mistakes of California, the country has recently slowed its efforts to make electricity markets more competitive.

Recommendations. Unless some technological "silver bullet" is found, our nation will increasingly be forced to choose between environmental quality and economic efficiency. "Green" sources of electric power will be attractive to consumers who are willing to pay a premium for it. Government-imposed renewable portfolio standards could increase costs, because renewable technology remains expensive. Consequently, most new generation will be fuel burning, adversely affecting air quality. Tradable pollution permits, where the right to pollute is sold by the government to the highest bidder, have emerged as an economically efficient and effective policy approach to reducing pollutants. The administration's proposal to invest $2 billion over the next ten years to further the development of clean coal technology is laudable. The government must also continue funding research in renewable generation and fuel cell technology to foster a diverse generation portfolio. On the demand side, consumers need clear price signals to encourage conservation and make rational trade offs between consumption and conservation. Real time pricing and metering, where demand is measured and priced on an hourly basis, can reduce electricity demand, the number of new power plants required, and the amount of greenhouse gases released into the atmosphere. Finally, protection of the physical infrastructure, as well as the information systems that support the delivery of electricity, is a critical need. Terrorists have already identified nuclear power plants and the transmission grid as high priority targets. Market economics favor efficiency, and the elimination of excess capacity. Policy makers must incentivize industry to insure we have a robust, redundant portfolio of electrical generation.

Nuclear Energy. Australia is adamantly opposed to domestic nuclear power generation, despite its role as a producer and exporter of uranium, while U.S. nuclear energy accounts for than 20% of all U.S. electricity generation and more than 40% of the electricity generation in ten states in the Northeast, the South, and the Midwest. Nuclear power provides a clean, cost-effective alternative to meet growing U.S. electricity demand. The U.S. nuclear power industry achieved its second straight year of record power generation levels in 2001, despite the fact that the industry now is operating 104 reactors compared to 111 in 1990. Nuclear energy remains one of the cheapest ways to produce electricity. Nuclear power plants had lower operating costs than natural gas and coal in 1999 and 2000.[27] President Bush's proposed National Energy Policy recognizes the key role of nuclear power and supports the building of new nuclear power plants.[28] Under the Bush administration, the Nuclear Regulatory Commission and the rest of the federal government have streamlined the licensing process for nuclear plants to speed up the timeline to build and operate new reactors.

Vulnerabilities. The events of September 11th particularly heightened concerns about the safety and security of the U.S. nuclear power industry. The temporary on-site storage facilities for spent nuclear fuel present the greatest risk. Thick-walled, steel-lined concrete containers surround these open-air spent-rod fuel pools. Although these cooling pools provide a relatively small and difficult target for terrorists, a pinpoint ground attack could drain a pool's water, causing the fuel to overheat and melt. However, even if the fuel were to melt, little radioactive particulate would be produced that might become airborne.[29] A second vulnerability is the fact that a nuclear power plant operates from external electricity. Electricity powers all critical aspects of plant operations. If a terrorist were to effectively disrupt a plant's electricity, and destroy or disable backup generators, a core emergency could ensue. Another vulnerability is the water intake pumps for the cooling process.[30] If these pumps were attacked and damaged, a core meltdown might occur. The nuclear power industry is aware of these risks and is employing rigorous security measures to respond to the heightened threat of terrorism.

Waste Disposal. The Nuclear Waste Policy Act of 1982 required DOE to dispose of spent fuel as of January 31, 1998. Since that time, the federal government has spent over $6.8 billion on feasibility studies for an underground site in Nevada's Yucca Mountain, located 100 miles north of Las Vegas.[31] Because of numerous engineering, political, and legal hurdles, Yucca Mountain is not expected to be ready to accept nuclear waste shipments before 2010 and possibly as late as 2020. However, the Bush Administration has announced its intention that Yucca Mountain will be the national repository for nuclear spent fuel and waste.

Recommendations. Given the declining availability of natural resources and increasing demand for electricity, nuclear energy is a key generation asset. Nuclear energy provides a clean and economical form of electric power. To facilitate a continued role for nuclear generation, the federal government should end its moratorium on the reprocessing of spent nuclear fuel. DOE should work with the nuclear industry and university research labs to develop an economical reprocessing technology. When this technology is fully developed, the reprocessing center should be built near the Yucca Mountain Repository for security and control. To address security concerns, policy makers should reinstate a comprehensive security review and testing program for nuclear power plant facilities.

Renewable Energy. The renewables sector of the energy industry is defined by its major sources, including hydropower, the burning of biomass as fuel, geothermal, wind, solar and hydrogen. The primary use of these energy sources is to generate electricity. Hydroelectricity's share of U.S. generation is approximately 6%, while non-hydroelectric sources provide approximately 2-3% of U.S. electricity needs. Over the past 20 years, the renewable share of total U.S. energy consumption has remained relatively constant. Given current technology and economics, DOE forecasts the renewable share of generation to be constant through 2020.[32] While hydropower is the most affordable and abundant source of renewable energy, dams have been criticized for impacting fish migration and other wildlife. In response, DOE is retrofitting all existing dams with new fish-friendly turbines. Even with this mitigation strategy, the environmental issues associated with new hydropower projects suggests little potential for growth. Non-hydroelectric renewable generation is currently not cost competitive with fossil fuel generation, such as natural gas. Although there are regional variations in price, in Texas for example, the capital, fuel, operating and maintenance cost of new natural gas generation is estimated at 3.4¢ per kilowatt hour (kWh), compared to 6.3¢/kWh for biomass, 20.3¢/kWh for photo-voltaic solar, and 4.8¢/kWh for wind. Geothermal electricity costs 3.0¢/kWh in states where it is available, but it is an extremely limited resource.[33]

Despite its vast sunshine inland, and ample winds, Australia has shown little interest in introducing renewable energies for power generation. This can be attributed to Australia's huge reserves of very low-cost coal and natural gas. As environmental debates heat up, or renewable energy costs fall, the willingness to consider these technologies may increase.

Challenges. In states that have chosen to keep electric power regulated, green energy programs, where consumers agree to pay a small premium for electricity from renewable sources, are being implemented by electric utilities. This approach is intended to ensure consumer demand remains at levels necessary to sustain continued R&D. Elsewhere, the restructuring of the electric utility industry to promote competition in generation presents a significant challenge for renewables. Consequently, twelve states have adopted a renewable portfolio standard (RPS) that requires a specified portion of electricity generation come from renewable sources. An RPS has the potential to increase average electricity prices slightly. DOE analyzed the impact of a national 10% RPS, and estimated that electricity price could increase from 6.2¢/kWh to 6.3¢/kWh. However, the net savings from such a program could be as high as $15 billion because of reduced overall natural gas demand, producing a price decrease. DOE is also funding R&D in the following areas to make renewable generation more cost-competitive: commercializing large scale biomass systems, solving geothermal technical problems, improving the cost effectiveness and reliability of wind energy, improving the commercial viability of solar photovoltaic (PV) technology, and supporting hydrogen fuel cell development. Wind turbine research is targeting a price of 2-3¢ per kWh by 2010. As these efforts progress, a continuing challenge for the government will be making the best investment choices among potential energy alternatives.

DOE has established a goal of reducing the price of solar electricity to 6¢ per kWh by 2010.[34] DOE is funding solar research at the Energy Research, Development and Information Centre (ERDIC) of the University of New South Wales, Australia, a world leader in high efficiency silicon solar cell research. ERDIC's long-range goal is the development of concepts and supporting technology for a high efficiency "third-generation" photovoltaic technology based on thin films. They are betting that improved thin-film energy conversion efficiency will be the area of highest impact for future research. Their objective is, within nine years, to have developed one or more of the most promising options to the stage where it can be commercially evaluated.

Over the long term, hydrogen fuel cells have the potential to transform the energy industry. Fuel cells work by converting hydrogen or a hydrogen-rich fuel to electricity, which then powers an electric motor. Hydrogen is an ideal fuel for it produces no emissions, can be produced from a wide variety of renewable resources, and contains three times more energy than gasoline (pound for pound). An Allied Business Intelligence (ABI) study concluded that fuel cells will be installed in tens of thousands of vehicles by 2004. By 2010, hydrogen fuel cell vehicles are forecasted to have 4% of the automotive market share.[35] Fuel cell technology still presents significant commercial and technical risks. Establishing the infrastructure to support widespread use of this technology presents an enormous hurdle. However, hydrogen fuel cells appear as a bright hope for our long term needs.

Recommendations. In light of this discussion, the following policy recommendations seem most appropriate. Establish policies to stimulate development of renewable technologies and grant tax incentives to stimulate the commercialization and use of promising technologies, such as hydrogen fuel cells and hybrid electric cars. Sponsor partnerships between public and private sectors to develop more energy efficient generation and consumption technologies. Fund R&D in renewable technologies.

U.S. National Energy Policy, *by Scott Clemons, Defense Contract Management Agency*. The U.S. National Energy Policy (NEP) Development Group, headed by Vice President Dick Cheney, presented its report to President Bush on May 16, 2001.[36] The group designed the policy to increase U.S. security by ensuring adequate energy supplies while reducing U.S. reliance on foreign energy sources. Since then, the administration's proposals have been a lightning rod for controversy. A goal of the NEP was to bring together business, government, local communities and citizens to promote a dependable, affordable and environmentally sound energy policy for the future.[37] However, the political environment associated with the energy industry has always been highly charged. There are opposing arguments on any issue. Every stakeholder in the energy industry or environmental lobby has political action committees and lobbyists representing competing viewpoints. The administration's panel relied heavily on energy industry leaders for technical expertise. Some have criticized this process as favoring industry views at the expense of environmental protection.

Development vs. Environment. In any analysis of energy policy, two diametrically opposed positions quickly become apparent. These two positions are those of the industry, promoting resource development, and those of the environmentalists, promoting alternatives to resource exploitation. Finding a middle ground is often difficult. This conflict quickly emerges in our thirst for oil. U.S. consumption of oil is expected to rise from 19.5 million barrels per day (bpd) in 2000 to 26 million bpd in 2020, an increase of 32%. At the same time, domestic oil production is expected to remain more or less flat, at about 9 million bpd. Net oil imports will have to rise to nearly 65%.[38] The NEP quickly created controversy over plans for expanding oil and gas exploration in Alaska. The leading Senate foe of the Bush administration's plan, Senator John F. Kerry, was able to keep the proposal calling for drilling in the Arctic National Wildlife Refuge (ANWR) in Alaska out of the Senate version of the NEP.[39] The *Washington Times* recently confirmed that even the oil companies did not support drilling in ANWR. Studies by the U.S. Geological Survey explained that Arctic oil is so expensive to get that it is barely worth extracting at current market prices.[40] Another controversy developed over proposals to expand drilling on the continental shelf in the Gulf of Mexico and offshore from the Atlantic and Pacific coasts. The opponents of ANWR and offshore drilling often argue that production from areas currently undeveloped, whatever their potential, wouldn't eliminate US reliance on oil from abroad.[41] While this is true, any increase in domestic production would help reduce U.S. dependence on foreign oil.

Demand vs. Conservation. U.S. energy resources are not keeping pace with our growing demand. In attempting to resolve this imbalance, U.S. policy makers face a dilemma. As long as the price of energy remains relatively low, we are going to continue to consume at ever increasing rates. There is little incentive for conservation. On the other hand, if the cost of energy increases, supplies will expand and consumers may begin to conserve. However, the political cost of letting energy prices increase may be prohibitive. The Bush energy proposals favor keeping prices low, with little emphasis on conservation. The problem with this outlook is that it ignores technological progress in energy efficiency, such as the development of energy saving appliances. The administration's NEP de-emphasizes further advancements by reducing U.S. government investment in energy conservation R&D. These efforts could produce major benefits. For example, new technology recently developed for air conditioners, which consume 28% of California's peak demand for electricity, would save enough energy to avoid the construction of 11 large power plants on the West Coast and 120 such plants nationwide by 2010.[42] Another area where conservation can have a positive impact is in automobile fuel efficiency standards. An amendment recently defeated in the Senate would have closed the so-called Sport Utility Vehicle (SUV) loophole, which designates SUVs and mini-vans as light trucks. This designation exempts these vehicles from the 27.5-miles per gallon required of ordinary cars. Although the potential reserves of ANWR are not fully known, by some estimates, closing the SUV loophole could result in oil savings of more than 1 million bpd by 2015, considerably more than ANWR would be expected to produce in the same time frame.[43]

Restructuring of the electric utility industry. As part of state electric restructuring schemes, vertically integrated and regulated electric utilities are reorganized into competitive electric generation operations while transmission and distribution systems remain regulated. To facilitate competition at the wholesale level, the Federal Energy Regulatory Commission (FERC) requires utilities to provide open access to their transmission systems at non-discriminatory rates for other power generators.[44] Recently, technological advances in generation have facilitated distributed generation, where smaller electric power plants are dispersed along the transmission grid. Since this form of generation is less capital intensive, it favors entry by smaller firms, and supports a competitive environment. The Bush energy plan promotes competition in the provision of electric power by recommending improvements in the interstate transmission system, which would result in larger, more open, and hence, more competitive markets. However, state governments are ultimately responsible for the regulation of electric utilities at the retail level. Even Republican-controlled state governments are unlikely to support the intrusion of the federal government into retail electricity restructuring by states.

Increasing energy supply vs. pollution. The Bush energy plan is clearly focused on promoting greater availability of energy from coal and oil. In addition to the already-mentioned proposals to develop oil reserves, the NEP advocates the investment of $2.2 billion in "clean coal" technology, an effort to support and subsidize the coal industry. This addresses a short-term political opportunity. Because of the recent mild winter and relatively cheap supplies of natural gas, the coal industry is facing lower prices and tough times. The proposed investment would increase demand for coal through the development of pollution-control technology for generating electricity, helping coal become a more environmentally friendly source of energy.

One of the more controversial methods of reducing the amount of sulfur dioxide emitted into the atmosphere when coal is burned is the use of Tradable Pollution Permits (TPPs). These permits are issued by the Environmental Protection Agency to achieve sulfur emissions air quality standards. In order to meet these goals, aging coal fired generating plants must update pollution control equipment by adding sulfur scrubbers that remove the substance from emissions or by burning lower sulfur coal. Instead, the electric power and coal mining industries would like to see the use of TPPs averaged across all plants of a given corporation, allowing for market-based incentives for investment in pollution control upgrades. The NEP supports the development of regimes for TTPs. The use of these TPPs could also be extended to apply to carbon dioxide as well as other pollutants.

International parallels. Other countries are also grappling with these issues. The Council of Australian Governments is currently conducting a National Energy Review also. Their key challenges include strategic direction, government regulation, environmental concerns, and resource development and distribution. The review is identifying impediments to the full realization of the benefits of energy market reform as well as the strategic direction for further reforms. The regulatory approaches Australia is pursuing attempt to balance incentives for new investment, demand-side responses, and benefits to consumers. The environmental issues are focused on reducing greenhouse gas emissions.

Summary. The proposals contained in the National Energy Policy reflect a comprehensive effort to address U.S energy needs. The document has not satisfied all stakeholders in the energy arena, particularly those in the environmental lobby. However, it serves as a baseline to open debate in the Senate and House of Representatives. The domestic consequences of the Administration's proposals have galvanized environmentalists and opponents in the Democratic Party. Many of the issues we are facing are global in nature. The final shape of any legislation in this area will be the result of political tradeoffs, made in the glaring light of public and media attention. This will serve as an even greater test of Bush's political acumen.

Energy and the Environment, *by Phillip Ives, Department of State*. America's environmental industry is focused on reducing the environmental impact of development. Despite its relative anonymity, the environmental industry is quite large, even by U.S. standards, with nearly $200 billion in revenues and almost 1,400,000 employees.[45] So what is it, exactly? According to Environment Business International, the U.S. environmental industry can be broken into the following three segments:

- Service Segments: operations that obtain their revenues by collecting fees for services rendered. Among the services included in this segment are analytical services, wastewater treatment services, solid waste management, hazardous waste management, and remediation, consulting, and engineering.
- Equipment Segments: manufacturers that obtain their revenues from the sale of equipment, such as water equipment and chemicals, instrument manufacturing, air pollution control equipment, waste management equipment, and process and prevention technology.
- Resources Segments: entities that obtain their revenues from the sale of resources (e.g., water or energy) or reclaimed materials (like steel or paper).[46]

Although concern about the environment is not a new idea, the idea of responding to environmental issues as a commercial, profit-making activity can probably be traced to 1970, when President Nixon formed the Environmental Protection Agency. At the same time, the passage by Congress of the Clean Air and Clean Water Acts of 1970 set in motion a series of environmental requirements with severe penalties for non-compliance. To meet the new legal requirements, many companies needed assistance, a demand that, in essence, gave birth to the environmental industry.

The energy industry produces regulated pollutants as a by-product of operations. For energy firms, the compliance system caused them initially to view environmental protection as a cost of doing business. “Environmental expenditures were seen by business as a necessary evil, rather than as a potential ‘win-win’ factor in economic and business terms.”[47] The system of legislated environmental controls produced a system of fixing environmental problems after the fact, so-called “end-of-pipe” solutions.

More recently, a new paradigm has emerged. The defining statement of this new attitude toward the environment was marked by John Browne, British Petroleum's (BP) CEO, in a lecture at Stanford University on May 19, 1997. In his talk, he set as a goal for his company the reduction of CO_2 emissions by 10% from 1990 levels.[48] Browne’s comments were noteworthy because he was the first leader to publicly challenge his own company to make improvements in environmental protection *independent* of government requirements.

Browne’s approach reflected recognition that “end-of-pipe” solutions are a drag on the bottom line and Wall Street, more than anything else, values profitability. Secondly, in spite of the progress that has been made in reducing pollution and dealing with contamination, the American public continues to place a high value on a cleaner environment. Thus, being seen as doing “the right thing” by the public is good business. Finally, business people are citizens, too. Many CEO’s have expressed their personal concern for improving the environment and contributing to society’s greater good.

Browne and others in the energy industry are the leaders of a trend that had begun in 1987 with ISO 9000 and continued in 1997 with ISO 14000 -- generic management system standards adopted by the International Organization for Standardization (abbreviated ISO). “ISO 14000 is primarily concerned with ‘environmental management,’ actions firms employ to minimize harmful effects on the environment caused by their activities.”[49] For many companies, ISO 14000 offered a roadmap for minimizing the cost of doing business in an environmentally acceptable manner. Despite these noble aims, environmental management did not necessarily add value to a company. Value from these efforts can only be realized in the long run. Chad Holiday, Chairman and CEO of DuPont, has coined a term for his company’s path to the future sustainable growth. “By this I mean, we must create both shareholder and societal value while we reduce our environmental footprint…”[50]

Economic and environmental historians of the future may determine that John Browne’s speech at Stanford marked the beginning of that future or at least the end of the beginning. “Browne’s talk shocked other oil companies and pleasantly surprised the environmental community.”[51] More importantly, Browne followed up his rhetoric with action. He instituted procedures within the company that required managers to meet his environmental goals. He also set about positioning BP as an environmentally friendly company.

His comments in a return speech at Stanford on March 6, 2001 outlined the new paradigm. He said that he did not think that there had to be a choice between development and the environment, noting “…I believe there is a huge commercial prize for those who can offer better choices which transcend the trade off.”[52]

Browne and others (Koch Petroleum Group and its BluePlanet gasoline; Honda and Toyota with hybrid cars, Ford with its TH!NK electric vehicles) have dramatically changed relationships between their firms and the environmental industry. They believe they are in the environmental industry because their companies are part of the environment. Business, responding to its own needs for bottom line earnings and top-line valuation, in addition to meeting environmental targets and social needs -- the so-called "triple bottom line" -- will ensure that the environment is not harmed.[53]

If this approach is broadly adopted, the environmental industry of the near future will look much different than it does today, simply because all companies will be concerned about their approach to the environment. It is, after all, only good business to increase value. In his 2001 speech at Stanford, BP's Browne offered his vision of the future. "The answer to the environmental challenge of economic growth is neither denial nor retreat…the paradox is that the answer to the problems created by development lies in more development. That has been the story of human progress so far, and I believe we are now seeing that story rewritten again."[54]

Technology, Research & Development in the Energy Industry, *by LTC John Torres, USAF*. A fundamental shift is taking place in the business practices of the energy industry. Deregulation is driving fierce competition. Companies are consolidating, merging, diversifying, and disaggregating for competitive advantage. Technology has always been an important part of incremental improvements, enabling firms to reduce costs and increase profits. However, incremental improvements alone are not enough in today's market. More and more companies are using technology to drive their business strategy and improve practices. Knowledge management, virtual collaboration, three-dimensional analysis of seismic data, and advanced robotics are becoming mainstream. These techniques increase productivity, mitigate risk, and enable competitive advantage. It is apparent in today's business environment that those companies that do not leverage technology will get left behind.

What leading edge energy companies are looking for today are the "game changers" – those technologies that by their very nature change the rules of the energy business. Firms are leveraging these "game changers" to deliver dramatically increased value to their customers and shareholders. In the upstream oil and gas sector, two technology solutions are revolutionizing exploration and drilling. The first, 3-D visual interpretation technology enables two or three geological engineers to conduct oil and seismic pattern analysis in less than 90 days, a task that previously took six engineers two years to complete. This represents an enormous difference in evaluating prospective drilling sites.[55] This technology is paired with another technology called the Highly Immersive Visualization Environment, or HIVE. The HIVE provides a company's engineers with the capability to analyze a single source 3-D seismic image simultaneously, while geographically separated at multiple worldwide locations. It thus facilitates "virtual" multi-disciplinary teamwork, collaboration, and productivity breakthroughs.[56] Together, HIVE and 3D seismic modeling enable improved decision-making and risk mitigation strategies in less time. The result has been an unparalleled improvement in drilling project profitability. In the past, for every ten wells drilled, only two produced. Today, that number is increased to seven out of ten.[57] This is a profound advantage when the cost of a new offshore well can range anywhere from $10-$100 million.[58]

Advanced technologies are allowing oil companies to undertake offshore drilling at previously unimaginable depths. Wells in three and four thousand feet of water are becoming commonplace. Companies like Shell expect to be profitably drilling in depths up to 10,000 feet very soon.[59] Additionally, a single well can now tap multiple deposits, thereby further reducing overall well costs.

Another emerging technology for deep water gas production, as we learned in Australia, is the floating liquid natural gas (FLNG) platform. Instead of tapping the wells and then piping to shore, the self contained FLNG platform processes gas straight from the well head and then offloads it to LNG tankers for delivery to market or pre-designated customers. Currently under final development, the FLNG platform will be capable of producing previously stranded reserves without the need for large supporting land based infrastructure.[60]

Information technologies have facilitated the rapid growth of electronic market places across the energy industry for trading energy commodities, such as oil, natural gas, and electricity. These markets succeed because they produce tremendous reductions in transaction costs. Agreements that in past years would require months or years to complete can now be settled online in seconds.[61] Despite its parent firm's bankruptcy, EnronOnline is one of the most successful examples of these virtual trading floors. EnronOnline generated over $100 billion in transactions in its first 10 months of operation, selling 1,000 products in thirteen currencies.[62]

Currently in advanced R&D and demonstration, Australia's vanadium battery technology, developed with partial funding from the U.S. DOE, has the potential to revolutionize energy storage. Vanadium batteries employ two electrolyte solutions together in a medium that when combined, generate electrical power for immediate use or long-term storage. Unlike conventional batteries, vanadium batteries can store energy for up to 50-100 years. Total capacity is limited only by the amount of solution used. A 200 kW/800kWh vanadium battery system is now operational in Japan with overall energy efficiencies of 80 percent. Vanadium batteries may soon be replacing backup diesel generators in commercial applications, and eventually could also be installed on electric vehicles or in military systems such as submarines for emergency power.[63]

Technology applications are also addressing emerging human resource (HR) issues. Two of the most critical HR issues to the energy industry are the aging knowledge worker and workforce productivity. Companies are using technology to capture, condense, and rapidly transfer knowledge from the experienced workforce to new hires. One such project under development is a "decision simulator". Similar to military aircraft simulators, the decision simulator will allow new hires to conduct project planning and make capital investment decisions in a controlled laboratory environment without actually expending capital resources.[64] As a result, new hire productivity can be greatly accelerated.

Shortcomings in Private R&D. For a new technology to be adopted by the industry, it must add value to a company's bottom line. With razor thin profit margins and the uncertainty associated with significant change, many companies are reluctant to invest resources in R&D. Additionally, the huge capital outlays and lengthy time horizons for new projects demand a critical assessment of the value of R&D efforts. Smaller companies often can't afford significant R&D expenditures. They may choose to adapt technology from other industries or leverage the technological innovations of energy solutions companies – companies whose core focus is to provide high-technology solutions.

Some firms with deep pockets are able to escape this dilemma. The Ford Motor Company is pushing ahead with the development of a small super fuel-efficient (gasoline-electric) hybrid SUV. It plans to deliver this vehicle to the market by the beginning of 2004. This development is proceeding entirely with private funding with no government incentives. [65] Landmark, a firm providing three-dimensional graphical modeling of oil and gas deposits, is graded on how well they provide innovative energy solutions to the industry. This firm doesn't drill wells; they make drilling more profitable and safer for the environment. Landmark invests heavily in R&D because it's key to maintaining competitive advantage.[66]

Recommendations. With the energy industry's focus on the bottom line, it is inevitable that R&D is under-funded. Can and should the government help? The answer is "yes" on both counts. The government should assist because of the criticality of the energy industry to U.S. economic prosperity and national security. The federal government has been promoting energy R&D since 1978 through DOE. DOE programs over the past 24 years have experienced mixed success. The following policy recommendations will provide DOE with a means to maximize the benefits of R&D.

1. Projects that receive direct funding should meet performance based guidelines that clearly delineate the requirements for continued program funding. If a program is not meeting the standard, it should be terminated.

2. The government should engage industry with public-private partnerships for R&D. Partnerships make both government and industry co-stakeholders in our energy future. Risks are shared. Public benefits from successful R&D efforts are assured. As an example, President Bush launched a $2 billion, 10-year clean coal technology initiative that involves a partnership with private industry. Industry receives matching government funds for acceptable proposals. Both industry and government share costs and risk.[67]

3. The government should push development of next generation ("leap ahead") energy technology from hydrogen and fusion. These technologies aren't commercially profitable at this time. Government can leverage the efforts for academia, private industry, and publicly funded research institutes. This is an appropriate focus for government efforts because it falls in the category of basic research.

4. The government should fund basic research on renewable energy. Currently, renewables are, for the most part, not competitive commercially. Global warming, resource scarcity, and the environmental impact of non-renewable energy production and consumption suggest a long term need to decrease our reliance on carbon intensive fuels.

<u>Mitigating Security Threats to the Energy Infrastructure, *by LTC Kathleen Pedersen, US Army*.</u> Our economy, and the energy industry in particular, rely upon interdependent and cyber-supported infrastructures. Information systems are essential to the operations of telecommunications, energy, banking and finance, transportation, water systems, and emergency services, both governmental and private. Non-traditional attacks on our infrastructure and information systems may be capable of significantly harming our economy and hence our national security.[68] Threats and vulnerabilities fall into seven general categories:

1. **Information Technology and Telecommunications.** Energy firms depend heavily on information technology and telecommunications. The changes caused by the information revolution and computerization have truly been transformational, and penetrate every aspect of our lives. In many areas, we are already well past the point where we could implement a manual back-up system, should electronic systems go down. Energy firms are absolutely committed to these technologies in our society, for they provide instant availability of information and enable instant communications. The reliance on cyber technologies creates the opportunity for interrupted communications, false or misleading transactions, fraud, or breach of contracts.[69]

2. **Globalization.** Energy firms are often multi-national. They, and the national economies they are a part of, can no longer be viewed in isolation. Economic interdependence increases risk, particularly in light of the vast differences in core values across cultures. In a

globalized economy where businesses are, either directly or by contracting or partnering, using other countries' labor, it's more difficult to be assured of the integrity of the workforce.

3. **Business Restructuring/Organizational Changes.** Energy firms are changing the ways they structure themselves for success, which leads to a less stable work environment for employees. With continued emphasis on cost reductions, employees are often let go or non-critical functions are outsourced. Information technology functions are frequently not seen as a core competency of the firm, and are also outsourced. This gives contract employees intimate knowledge and access to the firm's innermost workings.

4. **Interdependencies Among Interrelated Critical Infrastructures.** All infrastructures are dependent on information technology, telecommunications, and electrical infrastructures. Should these fail, businesses and critical services that depend on these infrastructures will also fail. Linkages between infrastructures are becoming so embedded in the way we do business that no particular infrastructure can be viewed in isolation. Often, the interdependencies between infrastructures increase the risk of intrusion into a firm's information (IT) systems.

5. **Political and Regulatory Issues.** Political and regulatory uncertainty makes it difficult for industries to make long-term strategic decisions. Investments in infrastructure are all based on an individual company's investment strategy. Regulatory changes can make it difficult to fully estimate the return on these investments and assess potential liabilities, keeping some companies from making critical investments to improve infrastructure. There is a conflict between the national desire to have a robust, resilient infrastructure that can withstand attack or be rapidly reconstituted, and company profits. This significantly impacts critical infrastructure protection.[70] In addition, laws are slow to adapt to the rapid changes. Second and third order implications of new laws are often not understood. For example, CAAA 90 mandated that Risk Management Plans (RMP) be written for various industrial facilities, including oil refineries and natural gas processing facilities. These plans required facilities to prepare "worst case scenarios" and include very sensitive offsite consequence analysis information. Congress did not provide any specific mandate restricting RMP information in the CAAA 90, and there was no generally applicable law to prevent the Environmental Protection Agency from posting the RMP information on the Internet. The EPA was considering making this information publicly available. Only after widespread opposition from law enforcement and intelligence agencies concerned about terrorist acts and economic espionage did the EPA decide to restrict the most sensitive portions of the RMP from the Internet.[71]

6. **Physical and Human Factors.** Energy infrastructures are capital intensive, with significant physical assets. Through human error or physical vulnerability, one component, multiple components or the entire infrastructure system could be placed at risk.

7. **Natural Disasters**. Naturally occurring disasters can have major consequences in the U.S., but we do have extensive plans and preparation to deal with them. This is not always the case in other, developing nations, on whom we might rely in today's globalized economy.

These issues have been known for some time, although recent events have highlighted their importance. In July 1996 President Clinton established the President's Commission on Critical Infrastructure Protection. This commission was chartered to assess the vulnerabilities of infrastructures and recommend a national policy and strategy to protect them. The commission published its report in October 1997. This was the first time that energy infrastructures were assessed. They were deemed critical national assets. In May 1998 President Clinton issued

Presidential Decision Directive 63 (PDD 63), *Protecting America's Critical Infrastructures*, to develop security plans by infrastructure sector. In February 2001 President Bush reported to Congress the progress made by government and industry towards achieving PDD 63 goals. The nation continues to work in all areas of PDD 63.

Recommendations. How can we mitigate the vulnerabilities of the U.S. energy infrastructure? Both industry and government agree to institute a voluntary government-industry partnership. Regulatory efforts should be kept to a minimum, because they are slow, cumbersome, and likely to rapidly become outdated, given the pace of change. Almost 95% of critical infrastructures are owned and operated by industry, state, and local governments.[72] A cooperative partnership is seen as the most efficient vehicle to achieve real change, especially since the terrorist attacks of September 11, 2001. A partnership must work to achieve the goals set forth in PDD 63, which calls for elimination of the most significant known physical and cyber vulnerabilities of our critical infrastructure by May 2003. By this time, a mechanism must be in place to conduct periodic vulnerability assessments and remediation. The Critical Infrastructure Assurance Office (CIAO) is drafting a revised version of a national plan to determine and implement appropriate measures.

Recognizing the impossibility of completely securing all infrastructures, a cost-benefit analysis must be performed for the assets deemed less critical. As part of this process, countermeasure and trade-off costs must be calculated. For telecommunications and electricity generation, redundant systems are essential. We risk cascading failures in other infrastructures if these systems are disabled. Employees in selected, sensitive areas of the energy infrastructure should undergo background security checks, with periodic updates.

Existing laws must be modified, to:

1. Exempt communications with the government involving critical infrastructure protection from the Freedom of Information Act.
2. Facilitate information sharing among infrastructures members without fear of government accusations of anti-trust violations, where appropriate.
3. Tighten protection of confidential information.
4. Remove sensitive information that reveals infrastructure vulnerabilities from the Internet. Study the possibility of restricting such information to those with a validated "need to know." Do not make such information available to the general public.
5. Educate businesses and critical services about cyber-security. Shield IT systems from cyber-attack via biometrics, intrusion detection, firewalls, proxy servers and other means.
6. Increase surveillance of physical assets and cyber systems. Such surveillance can be done physically and electronically, by sensors, cameras and other means, some of which are emerging technologies not yet ready for application.
7. Diversify sources for key materials and services in geographically separated areas, if such sources are not a security risk.
8. Monitor progress of the desired partnership between government and industry. Consider government regulation if market forces do not achieve the level of vulnerability mitigation desired.
9. Continue to refine the "Energy Infrastructure Vulnerability and Risk Assessment Checklists" for state governments, as a guide to assist them in their efforts.

Summary. The U.S. government and industry are applying prudent measures to correct our security vulnerabilities in our energy infrastructure. The Office of Energy Assurance at DOE is conducting the Vulnerability and Risk Analysis Program, to mitigate significant problems, improve infrastructure assurance, and develop lessons learned and best practices. As technology and the nature of the threats to our critical infrastructures continue to change rapidly, we must proactively adopt protective measures and responses.[73]

Electricity Restructuring, *by Kelly Morris, Defense Energy Supply Center*. Policy makers have been working hard over the past three decades to create an environment in the electricity industry where regulated utilities are transformed into efficient companies that offer innovative services in competitive markets. While some might refer to this as deregulation, restructuring is a more appropriate term, because the industry will remain heavily regulated for reliability and safety. Critics of restructuring have cast doubt on the viability of competitive electricity markets, based on the failure of retail restructuring in California and the perceived abuse of power by Enron and other marketers. However, if allowed to operate freely, wholesale and retail competitive markets can achieve their intended objectives while offering consumers increased service options. Attainment of these objectives will boost U.S. economic competitiveness, thereby contributing to our national security.

Electric Restructuring Defined. The primary objective of restructuring the electric power industry is to "substitute market forces for regulation where economically appropriate."[74] It is based on the premise that market forces in a competitive environment lead to greater efficiencies because prices are more reflective of their underlying economic costs.[75] Competitive markets incentivize firms to use the minimum resources necessary to produce a certain output level. Competitive markets also promote continual innovation that may have been otherwise untapped in a regulated industry.[76]

Typical components of restructuring include requiring vertically integrated public utilities to unbundle functions such as generation, transmission, and distribution. Some utilities sell their generation assets. Others develop non-regulated marketing subsidiaries, which then compete against other power producers bringing electricity to market. Deregulation of transmission and distribution has not been considered because of safety and reliability. Multiple sets of transmission lines are simply not an efficient means of serving customers.

The need for change. Changes in policy-makers' mindsets, technological advances, and disparate pricing of electric power across regions have pushed the electricity industry into a deregulated environment. Initial efforts to restructure the industry can be traced to 1978, when the federal government enacted the Public Utility Regulatory Policy Act (PURPA), one of five statutes aimed at reducing U.S. dependence on foreign oil.[77] This law required utilities to buy power from independent power producers (IPPs). The Federal Energy Regulatory Commission (FERC) was made responsible for regulating wholesale transactions between utilities and IPPs over interstate lines. FERC issued Order 888, which ensured open access to the transmission grid for all power providers. FERC also issued Order 889, which required utilities to establish electronic systems for sharing information about available capacity on the transmission lines.[78] In 1999, FERC Order 2000 followed, which encouraged utilities to turn over control of transmission lines to Regional Transmission Organizations (RTOs).[79] Other key aspects affecting the provision of electric power, such as who should control, regulate, and provide backup capacity on transmission lines, are still being debated by state and federal policy makers. While legislation laid the framework for electric restructuring, technological innovation signaled the need for change in the electricity industry. Innovations in the generation of electricity, such as improved aero-derivative gas turbine technologies, now allow power generation plants to be built quickly and cheaply.[80] The final driver for electricity restructuring was in the area of pricing. Under the framework established by PURPA and the FERC orders, a wholesale power market between utilities and IPPs developed during the 1990s. The recognition of significant regional differences in the price of electric power served as a catalyst. High cost states believe competitive markets will reduce prices.

Retail Restructuring. Wholesale restructuring was largely completed through FERC Orders 888 and 889. Restructuring for retail competition at the state level is slowly making progress. Twenty-five states have adopted strategies that allow end users (firms and individuals) to select their electric power provider. Retail competition facilitates competition among suppliers to lower prices and increase innovation.

While customer choice at the retail level sounds like an attractive alternative to paying a high regulated price by the local utility, it does require consumers to actively look at the cost of electricity and evaluate whether to switch from a known provider, the incumbent local utility, to a new supplier. In fact, one of the hurdles to electric restructuring is that many residential consumers remain with the incumbent utility because of the price and supply uncertainty surrounding third party suppliers.

International. The U.S. is not alone in restructuring its electricity market. Electric utilities have been privatized and restructured in a number of countries including the United Kingdom, Australia, Argentina, and New Zealand. For example, the National Electricity Market in Australia began in December 1998 to promote competition in generation. Electricity at the wholesale level is managed in a pool-style spot market which matches generation with supplies needed at the retail level. In one of the few remaining pool-style operations, supply and demand is continually balanced by the National Electricity Market Management Company (NEMMCO). While wholesale restructuring has been successful thus far, full retail competition allowing free choice for consumers, is just being introduced. Australia faces similar problems to the U.S. Wholesale prices reflect market conditions while retail prices are capped and the retail market design represents high risk for small consumers. Regulatory issues at the retail level remain problematic.

Challenges. Overcoming political and regulatory obstacles is probably the biggest challenge that restructuring advocates face. Although half of the U.S. has adopted a competitive retail strategy, a flawed system in California and the fall of Enron caused many states to slow down or halt progress in restructuring. With the FERC prohibited from regulating state retail markets, the stage is set for a battle between state and federal policy makers. In its National Energy Policy, the Bush administration advocates a common framework for all states that facilitate competitive interstate commerce in electric power.

Recommendations. Demand for electric power is forecast to grow sharply over the next twenty years.[81] The NEP recommended several policies that enhance free markets. One recommendation is that state and federal policy makers ensure barriers to competition are eliminated. The NEP proposes legislation that promotes competition, protects consumers, enhances reliability, improves efficiency, and repeals or reforms old laws.[82] The NEPD Group also recommended that FERC use its authority to “encourage investment in transmission facilities” and that the U.S. establish a “national grid.”[83] These recommendations are important preconditions for successful restructuring.

Clearly a common framework for all states is necessary. Those states that have adopted a retail competitive structure should be rewarded with lower transmission tariffs for electricity flowing into their states. Non-conforming states should be subject to higher transmission tariffs to incentivize them to adopt a retail plan. Policy makers should also consider establishing a report card system to assess performance of restructuring efforts to determine if wholesale and retail competition have made the grade with respect to obtaining economic and technical efficiency in the market.

Conclusion. The electricity market is in a state of transition, transforming from a monopolistic, vertically integrated industry into a more efficient competitive marketplace. The industry has made significant progress towards substituting market forces for regulation where it is economically feasible. Market forces are driving firms to operate at efficient levels and implement technical improvements. As states continue to restructure the retail market, consumers will have the ability to choose the provider that suits them best. Challenges abound as the U.S. and the world continue to restructure their electricity industries, while ensuring the security of critical infrastructure. Strong policies that enhance competition at all levels and properly prepare for future generation and transmission demands will ensure electricity flows freely.

Energy Industry Summary. The critical role of energy in U.S. society demands a comprehensive, integrated energy policy. Defining such a policy will be a difficult, contentious undertaking, because there are many tough issues where the opposing arguments are sound and strongly advocated. We face difficult trade-offs between resource exploitation and conservation, environmental quality and economic development, security and openness. Some issues of these will be resolved by finding “win-win” solutions that please all parties, but more likely, the final form of our policy will reflect political bargaining and prudent compromise. Our analysis has approached the major policy issues without preconceived bias to offer what we feel provides the greatest good for the greatest number. Hopefully, this effort will add to enlightened debate. Whatever the policy outcome, we cannot continue to side-step these challenges because of the immediate impacts on our national security, and the long run impacts on future generations.

Endnotes

[1] Energy Information Administration (EIA), U.S. Department of Energy. *Energy Price Impacts on U.S. Economy*. Retrieved on April 20, 2002, from http://www.eia.doe.gov/oiaf/economy/energy_price.html.

[2] Ibid.

[3] EIA. *Annual Energy Outlook 2002*. Retrieved on April 20, 2002, from http://www.eia.doe.gov/oiaf/aeo/index.html.

[4] Ibid.

[5] EIA. *Oil Natural Gas Coal Electricity Environment Profile - United States of America*. Retrieved on Nov 9, 2001, from http://www.eia.doe.gov/pub/oil_gas/petroleum/analysis_publications/oil_market_basics/Supp.

[6] EIA. *Energy Situation Analysis Report*. Retrieved on March 19, 2002, from http://www.eia.doe.gov/emeu/security/esar/esar.html, p 2

[7] EIA. *Annual Energy Outlook 2002*. Retrieved on December 20, 2001, from http://www.eia.doe.gov/oiaf/aeo/index.html p 2.

[8] British Petroleum. (2001). *BP Statistical Review of US Energy June 2001*. London, UK. pp 22-23.

[9] Alexei Barrionuevo, John J. Fialka and Rebecca Smith, (2001, January 3). Federal Policies, Industry Shifts Produced Natural Gas Crunch. *Wall Street Journal*.

[10] EIA. *Natural Gas*. Retrieved on March 19, 2002, from http://www.eia.doe.gov/pub/oil_gas/natural_gas/analysis_publications/natural_gas_infrastructure_issue/pdf/nginfrais.pdf.

[11] Deutsche Bank AG. (2002). *Kings of the Wild Frontier*. Frankfurt, Germany. p 4.

[12] EIA. *Natural Gas*. Retrieved on March 20, 2002, from http://www.eia.doe.gov/pub/oil_gas/natural_gas/analysis_publications/natural_gas_infrastructure_issue/pdf/nginfrais.pdf.

[13] Armistead, Thomas F. The Nation's Natural Gas System is Under New Pressure to Deliver. *Engineering News Record*, January 29, 2001, p 1.

[14] EIA/Natural Gas Division. *Natural Gas Transportation – Infrastructure Issues and Operational Trends*. October 2001, p 5.

[15] Armistead, Thomas F. The Nation's Natural Gas System is Under New Pressure to Deliver. *Engineering News Record*, January 29, 2001, p 1

[16] Deutsche Bank AG. (2002). *Kings of the Wild Frontier*. Frankfurt, Germany. p 12.

[17] Ibid. 18.

[18] Davis, Kathleen. (July 2001). Coal fires back, regains championship title. *Electric Light & Power*, 79(7), p 2.

[19] Holmes, Connie. National Mining Association. *Coal: Domestic Energy for the Economy*. Briefing at Industrial College of the Armed Forces, January 24, 2002, slide 9.

[20] Ibid.

[21] EIA. *The U.S. Coal Industry in the 1990's*. Retrieved May 21, 2002 from www.eia.doe.gov/cneaf/coal/special/fig5.html

[22] National Energy Policy Development Group. (2001, May). *National Energy Policy Report to the President.* (pp 1-6).

[23] Silverstein, Ken. (1993, February). The Beauty of Coal. *Utility Business*, p 3.

[24] United States Energy Association. *The California Energy Crises*. Retrieved May 21, 2002 from www.usea.org/workingfiles/emdipresentations.htm.

[25] Resource Data International. (2001). *Outlook for Power in North America*. Boulder, CO: Financial Times Energy. p 12.

[26] EIA. *Electricity Generation by Fuel*. Retrieved on March 19, 2002, from www.eia.doe.gov/oiaf/aeo/images/figure_4.gif.

[27] Yelverton, Jerry. (Aug 15, 2001). Vital Speeches of the Day. *Nuclear Engineering*, 67, p 658.

[28] National Energy Policy Development Group. (2001, May). *National Energy Policy Report to the President, Chapter 5*. (p 15).

[29] Ibid. p.83.

[30] Interview with US Navy Commander Thomas Brown, Seal Team Leader, March 27, 2002.

[31] Hand, Mark. (Mar 1, 2002). The Saga of Yucca Mountain. *Public Utilities Fortnightly*.140. p 40.

[32] EIA. *Energy in the United States: A Brief History and Current Trends*. Retrieved on March 20, 2002, from http://www.eia.doe.gov/pub/pdf/mult.fuel/aer1999/sec1.pdf.

[33] EIA. *Annual Energy Outlook, 2002*. Retrieved on April 17, 2002, from www.eia.doe.gov/oiaf/aeo/electricity.html.

[34] U.S. Department of Energy. *Energy Efficiency and Renewable Energy Network.* Retrieved on March 21, 2002, from http://www.eren.doe.gov/pv/.

[35] Atakan Ozbek, K. (May 2000). Automotive Fuel Cell Markets. *Allied Business Intelligence*.

[36] National Energy Policy Development Group. (2001, May). *National Energy Policy Report to the President*.

[37] Ibid.

[38] Klare, Michael T. (2001, July 23). Energy Imperialism. *The Nation*.

[39] Milbank, Dana. (2002, January 22). Sen. Kerry to Offer Alternative to Bush Energy Proposal. *The Washington Post*.

[40] Krugman, Paul. (2002, March 15). Alaska National Wildlife Reserve and Peas. *The New York Times*.

[41] Anonymous. (2001, August 6). Energy Policy Dilemma. *Oil and Gas Journal*.

[42] Anonymous. (2001, March 21). A Dirty Energy Policy. *The Los Angles Times*.

[43] Anonymous. (2001, August 1). An Unenlightened Energy Bill. *The New York Times*.

[44] National Energy Policy Development Group. (2001, May). *National Energy Policy Report to the President.* pp. 5-7.

[45] U.S. Department of Commerce. (2001, May). *Environmental Industry of the United States.* p.1.

[46] Berg, David R., and Ferrier, Grant. (1998, October). Meeting the Challenge: *U.S. Industry Faces the 21st Century – The U.S. Environmental Industry*. U.S. Department of Commerce. pp. 16+.

[47] Ibid. p.11.

[48] Browne, John. *Climate Change Speech.* Retrieved on: April 5, 2002, from: http://dieoff.org/page106.htm.

[49] ISO, International Organization for Standardization (ISO). *ISO 9000 and ISO 14000 in Plain Language.* Retrieved on: March 24, 2002, from: http://www.iso.ch/iso/en/iso9000-14000/tour/plain.html.

[50] Holiday, Chad. (1999, November 17). *Sustainable Growth: DuPont's Goal for the 21st Century*. Greening of Industry Conference, University of North Carolina at Chapel Hill.

[51] Worldwatch Institute. Retrieved May 20, 2002 from http://www.ecoworld.com/air/articles/articles2.cfm?TID=97.

[52] BP, Browne, John. (2001, March 6). *A Progress Report.* Retrieved on: March 22, 2002, from: http://www.bp.com/centres/press/s_detail.asp?id=100. Speech given for the 2001 Conradin von Gugelberg Memorial Lecture on the Environment, Stanford University.

[53] The term "triple bottom line" was coined by John Elkington, author and management consultant. It refers to the three prongs of corporate success: social, environmental, and financial accountability. For more detail, see *The EcoSTEPS Sustainability Tree.* Retrieved on: March 22, 2002, from: http://www.ecosteps.com.au/home.htm.

[54] Browne, op cit.

[55] Matthews, Bill. (2002, April 9). *The Value of Visual Interpretation Technology in E & P.* Magic Earth corporate presentation to ICAF Energy Industry Study at Magic Earth, Inc. Houston, TX.

[56] Anderson, Paul. (2002, April 9). *HIVE: Highly Immersive Visualization Environment.* Corporate presentation to ICAF Energy Industry Study at BP. Houston, TX.

[57] Ibid.

[58] Frasier, Curtis. (2002, April 4). Shell Gas & Power presentation to the ICAF Energy Industry Study at Shell headquarters. Houston, TX.

[59] Ibid.

[60] Lane, Mike. (2002, May 15). Woodside Energy presentation to the ICAF Energy Industry Study at Woodside headquarters. Darwin, Northern Territories, Australia.

[61] Poruban, Steve. (2001, April 16). Enron's Lay sees more e-commerce changes for industry. *Oil & Gas Journal,* 99:16. p. 32.

[62] Levesque, Carl J. (2001, October 15). Inside the IT nerve center. *Public Utilities Fortnightly,* 139:19. p. 19.

[63] Skyllas-Kazacos, Maria, Dr. (2002, May 13). Vanadium battery presentations to the ICAF Energy Industry Study at the Energy Research Development Information Center, University of New South Wales. Sydney, Australia.
[64] Gibson, John. (2000). Knowledge Management and New IT Architecture will Maximize Upstream Value-Creation. *World Energy,* Vol. 3, No. 2. p. 3.

[65] Shirouzu, Norihiko. (2002, March 7). Ford aims to sell a gas-electric SUV that will offer sizeable fuel efficiency. *The Wall Street Journal.* p. A2.

[66] Heinemann, Robert, Dr. (2002, April 8). Halliburton business strategy briefing to ICAF Energy Industry Study at Halliburton Energy Services. Houston, TX.

[67] President's Clean Coal Initiative Underway. (March 4, 2002). Retrieved on: March 22, 2002, from: http://fossil.energy.gov/techline/tl_ccpi2002sol.shtml.

[68] *WHITE PAPER: The Clinton Administration's Policy on Critical Infrastructure Protection: Presidential Decision Directive 63*. (1998, May 22). p. 1.

[69] Lesar, David J. (2001, June). *Securing Oil and Natural Gas Infrastructures in the New Economy*. The National Petroleum Council. p.5.

[70] Ibid. page 30.

[71] Ibid. page 31.

[72] Wong, Nancy J. (2002, January 19). *National Critical Infrastructure Protection – A Perspective and a Framework for Industry.* Briefing from the Critical Infrastructure Assurance Office. Slide # 16.

[73] *WHITE PAPER: The Clinton Administration's Policy on Critical Infrastructure Protection: Presidential Decision Directive 63.* (1998, May 22). p. 3.

[74] McDermott, Karl, Gordon, Ken, Taylor, William E., and Ros, Agustin J. (2000, January). *Essential Facilities, Economic Efficiency, and a Mandate to Share: A Policy Primer.* Edison Electric Institute. p. 6.

[75] Ibid.

[76] Ibid. p. 7.

[77] Energy Information Administration, U.S. Department of Energy. (2000, January). *The Restructuring of the Electric Power Industry, a Capsule of Issues and Events.* p. 10.

[78] Edison Electric Institute. (2001, February). *Key Facts about the Electric Power Industry.* p. 11.

[79] Ibid.

[80] Energy Information Administration, Department of Energy. (2000). *The Changing Structure of the Electric Power Industry 2000: An Update*. p. 42.

[81] Energy Information Administration. *Annual Energy Outlook 2002 with Projections to 2020*. Retrieved May 21, 2002 from www.eia.doe.gov/oiaf/aeo/index.html.

[82] Ibid.

[83] Ibid.

BIBLIOGRAPHY

Anderson, Paul. (2002, April 9). *HIVE: Highly Immersive Visualization Environment*. Oral presentation to ICAF Energy Industry Study at BP, Houston, TX.

Berg, David R., Ferrier, Grant. (1998, October). *Meeting the Challenge: U.S. Industry Faces the 21st, Century – The U.S. Environmental Industry*. Washington, DC: U.S. Department of Commerce.

Blumberg, J., Korsvald, A., and Blum, G. (1997). *Environmental Performance and Shareholder Value*. World Business Council for Sustainable Development. Cambridge, MA: MIT Press.

Boiral, Oliver and Sala, Jean-Marie. (1998). Environmental Management: Should Industry Adopt ISO 14001? *Business Horizons*, 41, Jan./Feb. 1998, pp. 57-64.

Browne, Sir John. (2001, March 6). *Speech given for the 2001 Conradin von Gugelberg Memorial Lecture on the Environment*. Stanford University.

Business Week Online. (2002, February 11). *Running the Fuel-Cell Marathon*. Retrieved from: www.businessweek.com.

Clinton, W. J. (1998, May 22). *WHITE PAPER: The Clinton Administration's Policy on Critical Infrastructure Protection: Presidential Decision Directive 63*. Washington DC: White House.

Environmental Services Business. *International Trade Forum*. 2001. Issue 2.

Ford, Bill. (2000, October 5*). Keynote Speech to Annual Greenpeace Business Conference*. London, England.

Fossil Energy Techline. *President's Clean Coal Initiative Underway.* Washington, DC: Department of Energy. Retrieved on: March 04, 2002, from http://fossil.energy.gov/techline/tl_ccpi2002sol.shtml.

Frasier, Curtis. (2002, April 4). *Shell Gas & Power*. Oral presentation to the ICAF Energy Industry Study at Shell headquarters in Houston, TX.

Gibson, John. (2000). Knowledge Management and New IT Architecture will Maximize Upstream Value-Creation. *World Energy, Vol. 3, No. 2 – 2000*.

Global Environmental Management Initiative. (1998, November). *Environment: Value to Business*. Washington, DC.

Global Environmental Management Initiative. (1999, March). *Environmental Improvement Through Business Incentives*. Washington, DC.

Global Environmental Management Initiative. (2001, November). *Environment: Value to the Top Line*. Washington, DC.

Heinemann, Robert, Dr. (2002, April 8). *Halliburton Business Strategy*. Oral presentation to ICAF Energy Industry study at Halliburton Energy Services, Houston, TX.

Holiday, Chad. (1999, November 17). *Sustainable Growth: DuPont's Goal for the 21st Century*. Greening of Industry Conference, University of North Carolina at Chapel Hill.

Hun, Tara. (1998). Report: Rules No Longer Driving U.S. Environmental Market Demand. *Water Environment & Technology*, 10 (8), August 1998, pp. 20-21.

Johnson, Eric. (2002, April 9). *Introduction to Landmark Graphics*. Oral presentation to ICAF Energy Industry study at Landmark Graphics, Houston, TX.

Lane, Mike. (2002, May 15). Woodside Energy presentation to the ICAF Energy Industry Study at Woodside headquarters. Darwin, Northern Territories, Australia.

Lesar, D. J. (2001, June) *Securing Oil and Natural Gas Infrastructures in the New Economy, a report by the National Petroleum Council.* Washington, DC: Chairman of the Committee on Critical Infrastructure Protection.

Levesque, Carl J. (2001). Inside the IT nerve center. *Public Utilities Fortnightly,* 139:19 (Oct 15, 2001).

Marsh, R. T. (1997, October). *Critical Foundations – Protecting America's Infrastructures*. Washington, DC: Chairman of the President's Commission on Critical Infrastructure Protection.

Matthews, Bill. (2002, April 9). *The Value of Visual Interpretation Technology in E & P*. Oral presentation by Magic Earth to ICAF Energy Industry Study at Magic Earth. Houston, TX.

Morgheim, Jeff. (2002, April 9). *Energy and the Environment in the 21st Century*. Oral presentation by BP, p.l.c. to ICAF Energy Industry Study at BP, Houston, TX.

Office of Critical Infrastructure Protection. (2001, November 8). *Critical Infrastructure Interdependencies – Impact of the September 11 Terrorist Attacks on the World Trade Center, (A DOECase Study).* Washington, DC.: U.S. Department of Energy.

Peerenboom, J., Fisher, R. (2002, April 12). *Energy Infrastructure Vulnerability Surveys and Assessments*. Argonne National Laboratory (sponsored by the Office of Energy Assurance).

Poruban, Steve. (2001, April 16). Enron's Lay sees more e-commerce changes for industry. *Oil & Gas Journal* 99:16.

Rubin, Debra K. and Powers, Mary B. (2000). Revenue Grows in Green Markets. *Engineering News-Record*, 245 (1), July 3, 2000, p. 36 (8p).

Shirouzu, Norihiko. (2002, March 7). Ford aims to sell a gas-electric SUV that will offer sizeable fuel efficiency. *The Wall Street Journal.*

Skyllas-Kazacos, Maria, Dr. (2002, May 13). Vanadium battery presentations to the ICAF Energy Industry Study at the Energy Research Development Information Center, University of New South Wales. Sydney, Australia.

Sundt, Nick. *We Do Need to Take Precuationary action now.* Oakland, CA, Global Change Electronic Edition, Pacific Institute for Studies in Development, Environment, and Security. Retrieved April, 2002 from: http://www.globalchange.org/profall/97dec23.htm.

U. S. Department of Commerce. (2001, May). *Environmental Industry of the United States*. Washington, DC.

U.S. Department of Energy. (2001, December 4). *Energy Infrastructure Vulnerability and Risk Assessment Checklists for State Governments, Draft Version 1.0*. Washington, DC: U.S. Department of Energy.

U.S. Department of Energy. (1999, July). *Petroleum: An Energy Profile 1999.* Washington D.C. DOE/EIA-0545(99).

U.S. Department of Energy, Energy Information Agency. *International Energy Outlook 2001 – Highlights*. Washington, DC. Retrieved from: www.eia.gov/oiaf/ieo/index.html

U.S. Department of Energy. (2001, September 25). *The U.S. Petroleum Refining and Gasoline Marketing Industry.* Retrieved from: http://www.eia.doe.gov/emeu/finance/usi&to/downstream/

Wilson, Robert C. (2000). EMS Implementation Receives a Federal Nod. *Pollution Engineering*, 32 (1), January 2000, p. 27.

Wong, N. J. (2000, January 19). Briefing on *National Critical Infrastructure Protection – A Perspective and A Framework for Industry*. Washington DC: Critical Infrastructure Assurance Office.