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Industry Study**

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ENERGY 2006

ABSTRACT: America's energy supply portfolio is influenced by a complicated blend of economics, national security, and diplomacy that transcend our borders. The rapid globalization of markets, shifting political alliances and increasingly intertwined layers of dependency, make even the most reasonable public policy decisions concerning energy subject to intense domestic and international scrutiny and perhaps unintended repercussions. The energy industry is in the midst of unprecedented geopolitical and economic uncertainty that requires a broad understanding of individual sectors in order to make coherent national security decisions. The fragility of the electrical grid, the increasing reliance on imported oil in order to sustain our transportation infrastructure, and the call for alternative and renewable energy sources to reduce oil dependency and reduce global greenhouse emissions, are examples of issues that cannot be solved in isolation. As a result, the 2006 ICAF Energy Industry Study seminar assessed domestic and international energy security by addressing five main themes: security, regulation, diversity of supply, efficiency/conservation, and leadership/public education. The seminar traveled to energy manufacturers, suppliers, distributors, researchers, educators, and regulators in Northern Virginia, Maryland, Pennsylvania, the greater San Francisco valley, and throughout Australia in order to obtain candid industry, academic and governmental assessments of major energy sectors. This report reviews the Energy Industry Study's research findings, and provides recommendations for policy makers to consider when prioritizing programs and funding for research, development, and infrastructure support vital to America's energy security.

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PLACES VISITED

Domestic

Stella Corporation, Arlington, VA
 H2Gen, Alexandria, VA
 Defense Advanced Research Project Agency, Arlington, VA
 Petroleum and Water Department, Ft. Lee, VA
 BP Solar, Frederick, MD
 Wheelabrator Technologies Clean Energy Plant, Baltimore, MD
 Defense Energy Support Center, Ft. Belvoir, VA
 Dominion VA Power Company, Leesburg, VA
 Dominion VA Power Company, Fairfax, VA
 Peach Bottom Nuclear Power Plant, Peach Bottom, PA
 Florida Power & Light Wind Farm, Livermore, CA
 Electric Power Research Institute, San Francisco, CA
 Energy Modeling Forum, Palo Alto, CA
 Pacific Energy Center, San Francisco, CA
 Valero-Benicia Refinery, Benicia, CA
 California Fuel Cell Partnership, West Sacramento, CA
 Calpine Corporation, Middletown, CA

International

Victorian Department of Infrastructure, Melbourne, Victoria
 Ceramic Fuels Limited, Noble Park, Victoria
 Power Trail and International Loy Yang B Coal Mine, Morwell, Victoria
 Department of Environment & Heritage, Canberra, Australian Capital Territory (ACT)
 Department of Engineering, Australian National University, Canberra, ACT
 US Embassy, Yarralumla, ACT
 Australian Defence College, Department of Defence, Canberra, ACT
 Department of Industry, Tourism and Resources, Canberra, ACT
 Snowy Mountains Scheme Information and Education Centre, Cooma, New South
 Wales (NSW)
 Tumut 3 Power Station, Jounama, Dam and Talbingo Reservoir, Cooma, NSW
 Centre for Energy & Environmental Markets, Sydney, NSW
 National Electricity Market Management Company (NEMMCO), Sydney, NSW
 Port Waratah Coal Services, Kooragang Island, NSW
 Port of Newcastle Corporation, Newcastle, NSW
 Australian Energy Regulator, Sydney, NSW

PART ONE: INDUSTRY OVERVIEW

INTRODUCTION

Effective energy management, conservation, and implementation of alternative sources of energy are critical to America's national security and future prosperity. Global economic and population growth will create a nearly 50% increase in demand for energy over the next 15 years. Total oil demand will increase from roughly 75 million barrels per day in 2000 to more than 100 million barrels per day in 2015. Natural gas usage will increase by more than 100% over the next 15 years, growing more rapidly than any other energy source (NIC, 2000, p 28). Despite current emphasis on developing and implementing renewable energy sources (hydrogen, solar, wind, geo-thermal) only eight percent of energy supplied worldwide is forecast to come from these sources by 2020 (NIC, 2004, p. 59).

America is highly reliant on many forms of energy. Costs for American gasoline are still low by global standards, and in spite of recent price increases, incentive and motivation to cut consumption remain low. In his 2006 State of the Union address, President Bush announced initiatives to reach a national goal of replacing over 75% of our oil imports from the Middle East by 2025. He also announced the Advanced Energy Initiative, providing a 22% increase in clean-energy research funding at the Department of Energy (DoE) (NEC, 2006). However, challenges to America's national energy security require more than simply reducing oil imports and increasing research funding. Significant improvements are needed in regulation, supply diversity, conservation, policy, and educational leadership.

The energy supply chain is exposed to significant security threats to raw material supplies (crude oil, liquid natural gas, coal), vulnerable power generation infrastructure, and distribution networks (major pipelines and high-voltage transformers). Natural disasters and political unrest lend credibility to the unpredictable nature of energy resources worldwide. Diversified energy resources are vital for future energy security. Policy and regulations lack unity of effort and must strive to reduce risk, encourage innovation, and improve efficiencies. Leadership in federal, state, and local levels must unify regulation, enforcement, and public conservation awareness. Many companies are researching common initiatives, but do so in isolation. The energy industry must work toward an economy of means and scale. Energy conservation must become a part of life, whether at home, in the workplace, or with the vehicles we drive. This report expands on the above issues, explores the energy industry sector in detail, and makes observations and recommendations to ensure the America's future energy security.

THE ENERGY INDUSTRY DEFINED

Energy plays a critical role in the security of the US because it provides the fundamental basis of American industrial, economic, and social activity. Within the US, most energy is derived from three primary sources: fossil fuels, nuclear energy, and renewable fuels. These energy sources are in turn used, in varying degrees, across four end-user sectors: transportation, industrial, commercial, and residential. While the term 'energy industry' is generic, the ICAF Energy Industry Study compiled its assessment in three major categories. First, transportation fuels were assessed because these fuels are responsible to a great extent for American dependence on imported oil, with associated negative effects on our economic and national security. Second, we examined stationary energy because the expectation of dependable energy for our businesses and homes is deeply intertwined in the fabric of American society. Finally, we examined the role of government in guiding the future of this part of our national strategy.

Transportation Fuels

Transportation fuels include those energy sources which enable ground, air and maritime transport of goods and people. In 2004, this sector accounted for 28% of US energy consumption (EIA, 2005). Within the transportation sector, the two major energy sources are petroleum products and alternative fuels. In this study, the petroleum products segment was reviewed in the context of the security of oil supplies, national refining capacity, demand-side pressures, and transportation fuel efficiency. Petroleum and related issues are further discussed in the section below addressing oil. The alternative fuels section discusses biofuels (such as biodiesels and ethanol), gas-to-liquid (natural gas and gasified coal), and fuel cell technologies. The section also examines the transportation sector's perspective on these alternative energy sources.

Stationary Energy

Stationary energy powers the industrial, commercial and residential sectors of the US economy. Industrial use accounts for 33% of total energy consumption. Coal and natural gas are the primary energy sources used to meet individual plant requirements for manufacturing and "off-grid" electricity co-generation. The commercial and residential sectors combined account for 39% of total energy consumption, primarily in natural gas (e.g. building heat) and electricity (EIA, 2005). This study analyzes stationary energy in the context of both primary energy sources (in the sections on natural gas, coal, and renewable energy) and the electricity industry, to include both an assessment of electricity generation and distribution issues.

The Role of Government

While market forces generally move industry towards increased efficiency and performance, they do not ensure that industry adequately supports national security requirements. This study includes a review of the US Government's role in ensuring economic and national security in the areas of energy self-sufficiency, efficiency and conservation. It also reviews the ability of the Department of Defense (DoD), as the largest single consumer of energy within the federal government, to bring about technological innovations in energy, just as it did in the development of nuclear power and high performance computing.

OIL

Current Conditions

America is dependent on oil, especially for transportation. Over 40% of the energy used in the US comes from oil. Worldwide demand is projected to grow by more than 50% from 2000 to 2025 due to anticipated growth in the international economy (Lovins & Datta, et. al., pp. 1-3). The oil industry is capital intensive and presents unique security and economic risks.

Challenges

Our oil supply security is tenuous, and supply cannot keep up with expected future demand. Today, the US imports twice as much oil as it did in 1973 when the Arab oil embargo caused more than a 3% reduction in GDP (Lovins / Datta, et al., p 9). Much of the world oil supply is in unstable regions of the world and must transit through vulnerable transportation chokepoints such as the Straits of Hormuz and Malacca in order to reach consumers. As easy sources of oil are depleted, production costs increase, and we are now also competing for these resources with other nations.

US refineries and pipelines operate at near capacity but there is little economic incentive for expansion. Despite regulations to maintain excess capacity, little room remains to respond to disruptions caused by natural disasters (e.g. Katrina) or terrorist acts. Local resistance to building new refineries and other infrastructure further restricts the industry from increasing capacity. In

addition, regulation sometimes causes economic damage and distorted market signals. For example, disparate state and local regulations result in the production of ‘boutique’ fuels, increasing costs because these fuels are not fungible.

Insufficient oil supplies also threaten international political stability. Increasing demand without increasing supply virtually guarantees escalating oil prices. The result may be internal political instability in developing countries and tensions among exporter and importer states.

Outlook/Industry Response

The 1973 Arab oil embargo reduced supply, increased oil prices, and subsequently led to consumer, industry, and government interest in alternative energy and conservation. Industry responded by investing in oil alternatives and the government passed legislation that encouraged and mandated energy conservation and efficiency. However, low oil prices in the 1990s reduced the economic incentive to invest in alternative energy sources. With the recent surge in oil prices, industry is again responding to changes in demand by offering hybrid vehicles, fuel cell powered automobiles, and biofuels. US dependence on imported oil will not wane in the short term, and because much of the world's oil supply is in the hands of state-owned companies, political forces will continue to impact the market. For example, if OPEC recognized that alternative fuel sources were threatening world demand, it could lower oil prices, reducing alternative energy investment and ensuring continued world dependence.

ELECTRICITY

Current Conditions

Electricity is fundamental to US economic security, and for that reason the sources of electrical generation capacity are of high strategic importance. Coal currently accounts for more than 50 percent of generation capacity, with nuclear (21 percent), natural gas (16 percent) and renewables (hydro, geothermal, wind, solar) supplying the balance (EIA, 2004). By 2020, demand for electricity is forecast to increase by nearly 50 percent, requiring the construction of 1,300 – 1,900 new power plants or more than one new plant per week (NEP). With demand for electricity growing faster than supply, ensuring the nation has access to reliable, affordable and environmentally sustainable electrical generation will pose major future challenges.

Challenges

Inconsistent regulations, overlapping jurisdictional requirements, and a pervasive NIMBY (Not In My Back Yard) attitudes have discouraged and delayed construction of new power plants and associated transmission infrastructure. The nation’s aging electrical transmission system is inadequate to handle expected new electrical loads. The inevitable consequence, particularly during seasonal peak loads (summer air conditioning and winter space heating) will be brownouts and blackouts. Furthermore, the highly interconnected transmission grid is vulnerable to breakdown, from both natural and possibly man-made causes. Safeguarding the infrastructure presents a security challenge of the first order.

Outlook/Industry Response

Over the next 15-20 years, coal will continue to account for about half of US electrical generation (NEP), including nearly all baseload requirements. However, atmospheric pollutants pose major environmental challenges. Natural gas will capture an increasing share of electrical generation capacity, accounting for about a third of the nation’s electricity (mostly peakloads) by 2020, but rising gas prices, limited supplies, and tight markets will challenge those seeking to keep electricity at affordable levels. Nuclear power has recently gained cachet as a climate-friendly fuel, but predictions of a “nuclear renaissance” may be premature in light of high plant

construction costs and the unresolved problem of safe disposal of spent nuclear fuel.

Renewable sources contribute only a relatively small percentage of electrical generation capacity. Wind, solar, and geothermal power offer environmentally “clean” sources of electricity, but the key to increasing their contributions is attracting sufficient private sector investment. Without that investment, renewables are likely to remain a boutique rather than mainstream source of generation capacity.

COAL

Current Conditions

Coal is the most abundant energy resource in both the US and Australia, with domestic reserves conservatively estimated as sufficient for over 200 years (Plunkett). Approximately 90% of coal in the US is used to generate electricity, producing over half of our electric power (800,000 MW total grid, (EPRI, 2006)) and 80% of Australia’s (40,000 MW total grid, Department of Industry, Tourism, and Resources). The remaining 10% is used in the production of steel. Coal is a desirable energy source because it is abundant and inexpensive, with low, stable costs. However, these advantages are offset by relatively high emissions of pollutants, particularly carbon dioxide (CO₂). Coal fired power plants account for one-third to one-quarter of the world’s total man-made CO₂, sulfur dioxide (SO₂), and nitrogen oxide (NO₂) emissions (Canine, 2005). The 1990 Clean Air Act has dramatically decreased SO₂ and NO₂ emissions in the United States and the EPA’s Clean Air Interstate Rule (CAIR) of 2005 will demand additional decreases. Costs associated with existing clean air technologies are not expected to result in significant electricity price increases (EIA, 2006c).

Challenges

Obsolete coal plants built in the 1950’s and 1960’s require re-tooling in order to take advantage of the best technologies available for meeting clean air standards and most efficient generation methods (Canine).

Outlook/Industry Response

Coal is projected to increase its share of total US electricity generation from 50% to 57% by 2030 (EIA, 2006c). Industry is responding to environmental regulations by developing two leading clean coal technologies. The first is carbon capturing and sequestration (CCS), in which carbon dioxide from burning coal is piped deep below the earth’s surface for permanent storage (Canine). The second is integrated gasification combined cycle (IGCC) power plants. Coal is chemically turned into a synthetic gas/liquid, just like natural gas/oil, and burned in a gas turbine. The resulting exhaust heat from the first turbine creates steam and turns a second generator. The US Government is funding a 1 billion dollar project called FutureGen to combine these clean coal technologies and produce hydrogen from a single plant, but is not expected to be online until 2013.

NATURAL GAS

Current Condition

The US is the largest single consumer of natural gas, using 22.4 trillion cubic feet (Tcf) or 24% of worldwide production in 2004. The next largest consumer, Russia, used only 15 % (BP, 2005). Within the US, 8.5 Tcf (38%) was used for manufacturing. Commercial and residential building sectors used 7.9 Tcf (35%) to fuel furnaces, water heaters, and other appliances. The electricity sector utilized 5.4 Tcf (24%) for electricity generation, and the transportation sector used the remaining 3% (EIA 2006c).

Natural gas is an attractive fuel for the industrial and building sectors because it is the cleanest burning fossil fuel, requires no on-site storage, and has been competitively priced with oil for heating. The electricity sector finds it attractive because natural gas-fired power plants support modular design, have lower upfront capital costs, and produce fewer emissions than coal-fired plants (EIA 2006c).

While the US produces 20% of natural gas worldwide (second only to Russia), it is also the largest importer, with Canada providing 2.9 Tcf through pipelines. An additional 0.6 Tcf is imported as liquefied natural gas (LNG), mostly from Trinidad and Tobago (BP, 2005).

Challenges

By the end of 2004, the US natural gas reserves were 186.9 Tcf, or less than 3% of remaining proven world reserves, while Canada and Mexico together contain just over 1% (BP, 2005). With a projected 0.5% annual consumption growth rate for North America, the US will most likely become increasingly dependent on LNG imports from other regions (EIA, 2005).

Europe is already heavily dependent on imported natural gas. While they have some supply, their imports are expected to rise from 20% in 2000 to 70% by 2020 (Buchan, 2002, p.106). These imports come mostly from Russia, which is the world's largest exporter, estimated to hold a third of the world's natural gas reserves. In addition, Russia has set the goal of being the supplier of choice for the Asian market and is aiming for 10% of the US market share in LNG by 2010. Russia's state-run gas monopoly, Gazprom, produces 90% of its gas and controls the region's natural gas pipeline network (Bahgat, 2005). Russia's regional monopoly allows it to use the threat of raising prices or withholding gas to ensure political cooperation from its European customers, and this threat will only increase as they expand into greater markets, including our own (Baran, 2005, p.1-5).

Outlook/Industry Response

EIA (2005) projects worldwide natural gas consumption will increase from 94.9 Tcf in 2004 to 156 Tcf by 2025, led by China, with a 7.8% annual growth rate. EIA (2006) also projects LNG imports to the US will grow to 4.1 Tcf by 2025 and to 4.4 Tcf by 2030. Most readily accessible onshore conventional natural gas in the 48 contiguous states has been exploited. New natural gas discoveries are expected to be smaller, deeper and more expensive to develop. However, as worldwide demand raises prices, development of unconventional sources will become commercially viable. For example, there is an estimated 320,000 Tcf of methane hydrates offshore in deep US waters, and 590 Tcf in Alaska's North Slope (EIA, 2006).

RENEWABLES and ALTERNATIVE ENERGY SOURCES

Current Condition

Renewable and alternative sources of energy are the leading candidates for supplementing, and ultimately replacing carbon-based sources of energy. Renewable sources of energy include hydropower, biomass, solar, geothermal and wind. Alternative energy sources may or may not be renewable, but may serve as substitutes or provide nontraditional technologies for carbon-based fuels. Nuclear and hydrogen fuels are regarded as clean alternatives to fossil fuels. Biofuels such as ethanol and biodiesel are renewable alternatives to traditional transportation fuels. In 2004, renewables accounted for 6% of all domestic energy consumed, and 9% of electricity production was from renewable energy sources (EIA, 2006a).

Challenges

Renewable energy sources currently suffer from market fragmentation, uneven demand, and higher absolute costs per energy measure. Externalities like environmental degradation and

defense of our oil supply chain add to the societal cost of carbon-based fuels, but they do not generate correcting market forces. Phasing in new energy sources must include a plan to phase out the old (i.e. oil) and make the transition attractive to the industry. Government action in the form of subsidies, favorable depreciation schedules, investment tax credits etc. are designed to help developing technologies reach the point where economies of scale and technological advances make renewables competitive.

Government intervention cannot anticipate or solve all externalities. For example, the solar panel industry currently suffers from a shortage of silicon refining capacity; despite government incentives this shortfall inhibits market expansion and drives up costs for photovoltaics (Fetters, 2006). Wind energy costs have been substantially reduced in the last ten years, but locations favorable to wind power are often far removed from the transmission grid, have maximum power production during off-peak times, and in some cases, are environmentally objectionable. Large-scale hydropower, perhaps the most cost-effective form of renewable electricity generation, has probably peaked in the US due to environmental concerns and water rights issues. Geothermal energy is another source of renewable electricity. However, energy deregulation and a lack of economic incentives, coupled with environmental constraints, have created an uncertain investment environment, stifling growth. Since 2000, biomass, largely in the form of ethanol and biodiesel, has been the largest source of renewable energy in the US (EIA, 2006a). Unfortunately, the biofuels market suffers from insufficient refining capacity, high production costs, uneven demand, and lack of a transportation infrastructure and retail distribution. In general, market fragmentation and higher absolute cost per unit of measure inhibit growth of renewable energy markets.

Alternative energy supplies may help reduce our dependence on imported oil and gas, but even these fuel sources present economic and environmental challenges. Nuclear power generation has remained at roughly the same capacity for the last 25 years due to a variety of factors. Obtaining permits from local, state and federal agencies is a multi-year process with no guaranty of success. In spite of the fact that nuclear power can produce large quantities of energy without emitting atmospheric pollutants, fears of accidents like Three Mile Island continue to concern large segments of the population. In addition, the problem of how to handle the necessary long term storage of nuclear waste materials has not been solved. Finally, high up-front fixed costs for plant construction, combined with ongoing regulatory burdens tend to favor coal and natural gas plants that are cheaper to build and have less of a regulatory burden.

Since hydrogen can be produced from virtually any feedstock, including fossil, renewable, and alternative fuels, it may eventually become a key energy source. However, hydrogen power technology is still immature, and faces host of limitations that must be overcome prior to large-scale development. Fuel cells remain expensive, and while hydrogen is abundantly available from both fossil and low-carbon fuels, extracting the hydrogen is an energy intensive process, which, depending on the feedstock used, may produce significant greenhouse gasses. The biggest problem, however, is the lack of a logistical infrastructure such as distribution and refueling stations needed to deliver the product on a large scale. (Sperling & Ogden, 2004)

Energy conservation occurs by increasing the efficiency of an energy requiring system or by reducing consumptive behavior. Conservation is in itself a cost avoidance measure and according to Sissine (2006), energy efficiency is as viable a resource option as coal, oil, or natural gas. In economic terms, energy efficiency is a demand-side management tool for avoiding additional power plant construction. Addressing the economics of conservation, Lovins and Datta (2005) stated that between 1975-2005 US energy consumption per dollar of GDP fell by 43%, creating,

in effect, the largest source of energy in terms of savings.

Outlook/Industry Response

Because alternative/renewable energy sources are not currently economically competitive with fossil fuels, there are inadequate short-term financial incentives to get these technologies past the many barriers to large-scale entry into the energy market. The challenge for our elected leaders is to act quickly and decisively to take advantage of political momentum generated by the current trends in fuel prices. When energy prices are relatively low there is insufficient political will to enact and enforce substantive energy policy legislation. The Energy Policy Act (EPACT) of 2005 set a Renewable Fuels Standard to double the nation's use of biofuels from 4.0 billion gallons in 2006 to 7.5 billion gallons in 2012. It also provided expedited procedures for energy production (like geothermal) on federal lands, and funded federal energy research and development programs. Specific tax incentive provisions of the EPACT include \$14.5 billion over 11 years to encourage domestic energy production and conservation (Holt & Glover, 2006). However, the bill lacked three major elements to significantly shift the nation away from fossil fuels: a national renewable portfolio standard (RPS), stricter Corporate Automobile Fuel Economy (CAFE) standards, and binding limits on greenhouse gas emissions (Weeks, 2005).

GOVERNMENT - GOALS AND ROLES

The energy requirements of the US and our allies cover a broad spectrum, to include electric power generation, industrial, residential, and transportation sectors, each with peculiarities and vulnerabilities. Every president since Richard Nixon has issued some version of a national energy policy. Most of these policies were reactive in nature, responding a supply or price-induced shock to the energy marketplace. Nearly all attempted to address energy independence, energy conservation, and develop alternative and renewable sources of energy. Prioritization and focus on a few key areas (e.g., energy security, expanding the use of alternative energy sources, and price stabilization) should be the short-term goal of any national energy policy, with a long-term vision that will not dramatically change with each succeeding administration.

In 2001, President Bush implemented a National Energy Policy and in 2005 he signed into law a comprehensive energy bill (the Energy Policy Act of 2005). In February 2006, he released the Advanced Energy Initiative, the latest in a series of Presidential energy programs designed to guide US energy policy. This initiative builds on the themes of securing our economic and national security by decreasing our dependence on foreign energy sources, increasing alternative and renewable sources of energy, and promoting energy efficiency and conservation. A major component of this policy is the application of US technological and innovative capabilities to develop and implement better hybrid, electric, and hydrogen powered vehicles, and to increase the production and use of ethanol for our transportation needs (NEC).

Affordable and reliable energy supplies are critical to our continued economic growth and national security. The US faces several important threats to our energy supply, including decreasing oil and gas resources, unstable and unfriendly states which use energy resources as leverage, and vulnerability of our production and distribution infrastructure.

Experts believe the best way to counter these vulnerabilities is through diversification and excess capacity (Bahgat, 2001, p.517). However, diversification of oil sources is not the only solution because oil prices are set in a global market. In order to reduce vulnerability to oil and gas exporting countries, all importing nations will have to decrease their dependence.

Market forces will eventually drive diversification towards increased use of alternative fuels. However, because state actors control such a large portion of the world's oil and gas supplies, it

is not in our best interest to wait until market pressures force the issue. The significant infrastructure expense required to implement meaningful change from primary reliance on oil and gas requires a large investment of capital over a long period of time. Industry is not willing and probably not able to make those investments while exporting countries have the ability to manipulate oil and gas prices. Thus, some government intervention is appropriate to encourage diversification now. Although the US has made some progress in these energy initiatives, a remodeled process is required to ensure that a realistic and achievable national energy strategy is developed. Specific steps include building a true consensus on the problem and getting the public engaged, establishing an independent Commission to plot the course ahead, and providing adequate funding to resolve the problem sooner rather than later.

Since such a large percentage of our petroleum use is in the transportation sector, it is important to expedite the production of vehicles capable of operating on alternative fuels. Lovins et. al. (2005) suggest one way to do this is for the government to implement "feebates" in which buyers would either pay a penalty or get a discount depending on the fuel efficiency of the vehicle purchased. They suggest that such a plan would be budget neutral (pp.186-191). However, that would only hold true if an equal number of gas saving and gas guzzling vehicles were sold. Other approaches would be to provide low-interest loans for retooling necessary manufacturing processes and mandating that a proportion of government vehicles be capable of using alternative fuels. Similar incentives could be used to encourage the use of lightweight carbon composite materials to decrease vehicle weight (Elhefnawy, 2006, p.111). All of these measures could be applied in ways to avoid long-term 'corporate welfare' and market distortions. Another serious barrier to energy source diversification is the supply chain. Even if affordable alternative fuel vehicles were available, there is no infrastructure in place to supply the fuels. One thing the US Government could do is to finance the necessary infrastructure changes. This sort of government intervention would "jump start" the diversification process without generating a long-term market effects. Another key component to decreasing the demand for oil and gas is to encourage conservation. Improvements to municipal mass-transit systems and incentives for their utilization would decrease automobile use. Stricter fuel economy requirements on vehicles are needed; in particular, the SUV exemption from CAFE standards should be eliminated.

Since much of the US refining capacity and infrastructure are concentrated in a small area along the Gulf Coast, this presents a vulnerability to natural disaster or terrorist attack. In addition, our refineries are not capable of handling all grades of oil, such as that coming from Canada's oil sands. It is not currently profitable for industry to build more refineries in the US due to public resistance and regulatory burdens. Unless we are prepared to increase the percentage of imported post-refinery petroleum products, it will be necessary to consider incentives to encourage construction of new refineries in other locations.

Historically, because it is a natural monopoly, the US has had a heavily regulated electric utility industry. The Federal Energy Regulatory Commission is responsible for regulating power at the wholesale level, while the states maintain regulatory oversight of retail electricity sales. Recent efforts to deregulate the industry at the federal level have caused problems because, with wholesale price no longer tied to costs, there is less incentive for companies to make capital investments, particularly in the transmission infrastructure. In some cases, state deregulation has further disrupted the industry when the retail price of electricity has fallen below contracted wholesale prices (Cope et. al, 2003, pp.235-236). These issues have made it particularly difficult for producers using more expensive fuels, such as natural gas, to compete with those using

inexpensive coal. The result is a decrease in total electric power production capacity.

In spite of difficulties in the transition to less regulation, the trend is towards greater and greater interconnectedness within the electric power grid. It might seem that reliability would be enhanced if the entire country were interconnected. In that scenario, if electric demand went up in one area, supply from another area could be used to meet the need. However, the weakness in having a single grid is that if something catastrophic occurred in one location, the entire country could be left without power. For example, a large-scale blackout in the US northeast that same year was caused by localized problems that cascaded through the system, heightening awareness of the perils of interconnectedness (ICF, October 2003).

Although it is technically feasible to prevent rolling blackouts, there are competitive behaviors which make these episodes more difficult to prevent. Because competing utilities do not want to share information about their anticipated demand, it is difficult to determine when fluctuations in voltage due to extrinsic problems occur until it is too late. In addition, transmission lines are increasingly utilized at near-maximum capacity, which also increases the risk that a small event anywhere along the grid will produce a widespread power failure. In order to lower the risk of these occurrences, the Energy Policy Act of 2005 included the formation of an Energy Reliability Organization with authority to enforce reliability standards (Bamberger, 2006, p.12). This is an appropriate governmental intervention. However, there currently is little incentive for utilities to invest the capital needed to increase the transmission capacity of the electric grid. It may be appropriate for the government to provide incentives to encourage utility companies to upgrade transmission capacity in congested areas (Buchan, 2002, 112).

One of the most important aspects necessary for the continued development of renewable and alternative energy and conservation in the US is strategic leadership. Recent steps by President Bush with regards to communicating our energy challenges to the public have been in the right direction but a more sustained effort is needed. A strategic communication and domestic public education program, similar to that of the 1970s, should be established to encourage the public to conserve and take part in energy efficiency efforts. This will help ensure substantial public will to support energy-related programs.

Lack of unity of effort is yet another governmental problem still requiring resolution. Currently, numerous federal agencies, as well as state and local governments promulgate policy. Their actions are not integrated or synchronized and often these policies and regulations conflict, especially for energy products sold and traded across regional and state boundaries. One painful example is the state and federal regulation of the electricity industry, which contributed to the 1996 and extensive 2003 blackouts in California and the Northeast (EROP, p. 163). One report had 55 pages “summarizing” incentives just on distributed energy (Smoots).

In order to integrate and synchronize these multiple levels of government, the DoE should be given the lead federal role for energy security. The 2004 reorganization of the DoE’s Office of Energy Efficiency and Renewable Energy (EERE) has been an improvement but there is more to be done (Sissine, p. 3). Portions of other agencies directly involved in energy efficiency, conservation and renewables, and their corresponding budget allocations should either be transferred to DoE control or be subject to DoE oversight. Additionally, Senators Lugar (R-IL) and Obama (D-IL) proposed establishing a Director of Energy Security to sit on the President’s staff, similar to the Director of the National Security Council (United States Congress, 2006). In addition, the creation of an independent, apolitical, Energy Policy Commission (similar in concept to the Base Realignment and Closure Commission) should be formed to support the DoE and the President’s Energy Advisor. These actions would go a long way in synchronizing both

domestic and foreign policy and providing a unified effort with regards to efficiency and renewables and reestablishing America as a global leaders in these areas.

In addition to providing leadership, the federal government should build on EPACT's 20% improvement goal for conservation by establishing an additional oil consumption reduction mandate, replacing 30% of its automobile fleet with hybrids (Lugar). The federal government should also send a strong conservation message by increasing the CAFÉ standards, including closing the SUV loophole. This was considered in the 2005 EPACT but was not approved in conference (Sissine, p.9). Additionally, government should continue to increase building, appliance and efficiency standards beyond those in EPACT, to keep demand from growing further. Simultaneously we must assume a position of global leadership in conservation and renewable energy use, leveraging the European Union's success with renewable portfolio standards, incentives and subsidies; Japan's success in cultivating a solar industry; and Brazil's success with ethanol (Lynch). We should use diplomatic power to further develop international partnerships to research, develop and manufacture renewable technologies, especially with China, India and Brazil similar to the recent initiatives of the Asia-Pacific Economic Council (EIA, 2006b). Leadership in these areas is critical to our future success in developing our own renewable energy markets and subsequently reducing our dependence on oil.

Finally, the DoD should take the lead in demonstrating that consistently applied conservation methods can be effective. According to the Defense Science Board, "The United States uses more petroleum each year than the next five largest consuming nations combined. Military fuel consumption for aircraft, ships, ground vehicles, and facilities makes DoD the single largest consumer of petroleum in America, perhaps in the world" (DSB, p.ES1). DoD can be a national leader by reducing its dependence on petroleum and be the agent of change for the nation. DoD can lead national efforts to reduce the 'addiction' to oil without degrading military effectiveness.

"Today, over two-thirds of the tonnage required to position the Army into battle is fuel. Naval forces depend daily on nearly a million gallons of fuel to operate around the globe. The Air Force, as the largest DoD consumer, spends greater than three-quarters of its fuel budget to deliver, by airborne tanker, less than 10% of its annual fuel usage" (DSB, p.ES1). As the leading single customer of petroleum products within the US, DoD consumes approximately 1.5% of the total petroleum consumed annually by the US; DoD has an obligation to reduce its dependence on petroleum. Furthermore, as the largest and most expensive department within the US government, it has a responsibility to set the standard and chart the path ahead in meeting the President's goal of reducing dependence by 75% on imported oil by 2025. DoD will need a cohesive strategic strategy-based transformation, and supportive policies and funding in order to lead the nation to its goal in reducing petroleum dependence.

To summarize, focused government interventions that provide incentives to move our transportation industry towards the use of more fuel efficient vehicles and the use of alternative fuels, such as feebates, stricter CAFE standards, and incentives such as low-interest loans to finance infrastructure changes, along with educational programs to encourage conservation will promote progress away from dependence on foreign energy sources. We must simultaneously work with our allies to ensure they also reduce their vulnerability to foreign energy exporters, because otherwise, we remain vulnerable as well. Partnering with developing nations will likewise ensure that global energy resources remain ample and available. Incentives to improve the capacity of our electric grid will help ensure that natural disaster or terrorist acts cannot disrupt large areas of the country with power outages. Finally, moving from fossil fuels to

alternative, renewable energy sources will help to protect us from environmental threats, such as global climate change. These steps need not generate corporate welfare, and need not disrupt market forces or drive up energy costs beyond where they are appropriate or manageable.

PART TWO: ESSAYS ON FUTURE ENERGY ISSUES

The following essays explore a variety of energy security issues that will require attention from Government leaders. First, a potentially abundant but little known energy resource found in methane hydrates is explored. Next, an overview of the nuclear power industry details the challenges of storing spent fuel on a long-term basis. The next essay details significant security threats to America's and Australia's electricity grids, and recommends initial corrective measures. An assessment of America's electrical grid provides recommendations for developing and implementing a distributed power system through economic, political, and technological solutions. Finally, our international students provide their perspective on ensuring the stability of energy supplies by expanding upon oil policy issues, energy supply from a European Union perspective, and how to ensure our future oil supply and reduce our national oil dependence. These essays reflect the views of the authors and provide additional perspectives on some of the issues facing the energy industry.

Methane Hydrates – Future Alternative to Natural Gas

Over the past 10-15 years, as oil exploration moved deeper and deeper, drillers frequently encountered pockets of solid, ice-like formations. Oil drillers avoided these patches of methane hydrates, considering them a nuisance and hazard. However, for the last 5-10 years researchers have pursued methane hydrates as a future source of methane gas energy.

Definition, Quantities, Extraction

Methane hydrates are methane gas molecules trapped inside solid ice like structures known as methane clathrates. When released from frozen water cells, methane hydrates burn rapidly. Their solid structure is so compressed that a single volume of hydrate cavity expands, or dissociates, to 180 equal volumes of gas at normal atmospheric pressures (Sloan, p 356). Calculated volumetrically, a single cubic meter of methane hydrate contains roughly 164 cubic meters of methane gas at sea level, and only 0.87 cubic meter of water (Lowrie & Max, p 2).

The United States Geologic Survey (USGS) estimates that worldwide there is twice the volume of carbon in methane hydrates than the carbon contained in all other fossil fuels on Earth combined. The estimated volume of natural gas hydrates range from 100,000 to 300,000,000 Tcf. In comparison, the estimated remaining global reserves of undiscovered conventional natural gas totals only 13,000 Tcf. Gas hydrates are concentrated in waters deeper than 500 meters (USGS), but have been found at depths from 440 meters to as deep as 2,400 meters (Raeburn, p.2). Hydrates are located mainly around the coastal US, Alaska, Canada, Japan, and in permafrost regions near the Arctic Ocean.

The most promising hydrate extraction method is decreasing pressure below hydrate equilibrium, allowing the methane gas to escape. Another option heats the hydrate above stability temperatures by using hot water or steam injection. The third method involves injecting an inhibitor, such as methanol or glycol, decreasing hydrate stability (USGS). Multiple test results point to an eventual use of pressure reduction, combined with heat, to dissociate maximum quantities of hydrate.

Until approximately five years ago, a major hindrance to hydrate extraction was cost, since petroleum and natural gas prices were relatively low. However, according to John Sullivan, of Natural Gas Week, per barrel oil prices and the cost per thousand cubic feet (Mcf) of natural gas have reached a point where pricing thresholds have crossed, making methane extraction economically feasible. Research and test results predict methane hydrate extraction will eventually be possible on a commercial scale for between \$4 and \$6/Mcf, competing favorably with natural gas prices, and equaling prices of imported liquefied natural gas (Boswell, p 6).

Opportunities for Energy Security

The Government must aggressively pursue commercially available methane gas, as their future benefits far outweigh the challenges. According to World Oil, if only 1-2% of total estimated methane hydrates were economically recoverable, they would provide an enormous, worldwide energy resource (Fischer, p 66).

Japan, India, and the US presently lead the world in methane hydrate research. Japan leads the world in methane hydrate research funding, investing \$90 million from 2001 to 2005, since it has few carbon-based fuel resources and imports a majority of its consumption. India invested \$56 million and the US authorized \$47.5 million during the same period (NCEP Paper, p.5), although actual funding appropriations fell short.

Development costs are high, estimated between \$8 billion and \$12 billion to bring methane gas from hydrates to the commercial market. Japan is expected to lead the way and may have commercially available methane from hydrates by 2018 (Sullivan, p.11).

The Methane Hydrate Research and Development Act of 2000 (Public Law 106-193) established the US methane hydrates program. Public Law 106-193 authorized \$47.5 million, but funding between 2001 and 2005 totaled only \$37.1 million (NCEP, pp. 5-6). The initial Methane Hydrate Research and Development Act of 2000 expired in 2005 and Congress renewed it as the Methane Hydrate Research and Development Reauthorization Act of 2005. The 2005 Act authorizes \$165 million from fiscal years 2006-2010 (MHRDRA, p.6), and Congress rolled provisions of the Methane Reauthorization Act of 2005 into the Energy Policy Act of 2005.

According to the DoE's Strategy for Methane Hydrates Research and Development, 2015 is the stated target date for methane hydrate production (NCEP, p.3). Other estimates vary widely, from as early as 2010, to as late as 2020 or 2025. Many research articles reference long-term implementation dates, but there is no evidence of established interim goals for methane hydrate development as a future energy source. The DoE must develop a comprehensive timeline and define interim target dates and development goals.

Conclusion

In the future, methane hydrates may provide an abundant fuel source. The Government must dedicate significant resources to mature the technology required to secure this energy source for the future. Funding levels must increase and be sustained until methane gas becomes commercially available. Research and development must be unified and work toward common goals. An aggressive, detailed timeline should be established and followed for commercial marketing. The abundant supply of methane gas from hydrates is vital to America's energy security, and successfully bringing this resource to future energy markets must become a priority in alternative fuel research and development initiatives. (Mr. Robert Haddix, DAF)

Revisiting Nuclear Power

Nuclear fission technology and uranium reserves ensure a sufficient supply of nuclear generated electricity for at least 50 years. Recycling of separated plutonium from spent fuel would increase the energy of today's uranium reserves by up to 70 times, enough for more than 3000 years (IAEA). Nuclear power safety regulations associated with the disposal of radioactive waste from electricity generation allow for one of our safest and most environmentally friendly sources of energy with zero particulate and carbon dioxide emissions. With safety regulations in place, the 103 operating nuclear power plants providing 20% of our electrical generation could be expanded to approximately 515, and provide all of our electrical needs. Issues related to capital startup costs, and where to safely store highly radioactive material for 10,000 to 300,000 years present the current barrier (NEI, 2004) to nuclear power plant construction.

Capacity factor is a measure of electricity production that compares actual generation to the maximum possible generation. The average capacity factor for US nuclear power plants was 56% in 1980, 66% in 1990, and 90% in 2005 (NEI, 2006). The increase in electricity produced from 1990-2005 is equivalent to adding 26 1000MW nuclear reactors to the grid (NEI, 2006). "The costs of producing electricity at a nuclear power plant-operations and maintenance plus fuel-have been declining over the past decade" (NEI, 2006).

The report of a major European/US DoE study of the external costs of various fuel cycles, focusing on coal, gas, and nuclear, was released in mid 2001 (Friedrich & Bickel). External costs are defined as quantifiable costs incurred in relation to health and the environment but are not built into electricity costs. If these costs were in fact included, the EU price of electricity from coal would double, and the price from gas would increase by 30. Thus, the report concludes that nuclear power is cost-effective.

Congress passed the Nuclear Waste Policy Act in 1982. In 2002, after more than two decades of scientific study and seven billion dollars in research, Congress and the President approved the development of a geologic repository at Yucca Mountain, Nevada. DoE studies project an additional \$58-184 billion (2001) that would be required in life cycle costs. The same study projects that the Nuclear Waste Fund, a congressionally approved ongoing tax of nuclear-generated electricity consumers (0.1 cent per kilowatt-hour of electricity used) would cover 70% of the costs (NEI, 2004). Challenges regarding subterranean disposal have already been solved. Because of breakthrough methods that evolved during construction (by DoE) and certification (by the EPA), New Mexico's Waste Isolation Pilot Plant (WIPP) is the world's first successful deep geologic repository for the permanent isolation of federal (as opposed to commercial) nuclear waste. Multiple studies state that its remoteness, size, and stable geological and climatologically features make it the safest place to store any type of waste. If enlarged or annexed, the WIPP could hold all US nuclear waste generated for decades to come (ISR).

Conclusion

The positive attributes of nuclear powered electrical generation by far outweigh negatives associated with the industry. In order to decrease exaggerated negative public perceptions, nuclear power and environmental organizations should make a coordinated effort to communicate factual information on the industry in layman's terms. The US should use the WIPP vice Yucca Mountain for radioactive waste storage. (CAPT Robert Bonner, USN)

Vulnerability of the Electricity Grid

Americans rely on the availability of electrical power and seldom consider the consequences of catastrophic failure. Direct attack or natural occurrence could destroy critical infrastructure for

far longer than we are currently prepared for. Increasing power demands from industry, terrorist attacks and other system shocks have spurred some independent action toward power security, but more could be accomplished through government-industry partnerships to plan and resource a secure supply grid.

Several factors contribute to current weaknesses in our electrical system. Cities that began as isolated centers are growing together. Systems to connect them cover long distances, and are nearly impossible to protect from innocent or malicious trespassers. Much of our critical equipment (e.g. power lines, transformers, high-voltage power supplies) are exposed and in remote locations. Security is inadequate against the current threat.

In addition, deregulation has encouraged efficiency, invested-cost utilization, and return on investment rather than redundancy, reliability, and security. The quest for efficiencies and lower costs has resulted in under-investment in infrastructure. Utilities have also reduced their support for research and development; in particular, protection schemes for countering cyber threats seriously lag behind rapidly advancing cyber weapons (NRC, p.183). This is not intended as a criticism of deregulation or an implication that regulation automatically results in more secure infrastructure. However, the move to deregulation may have inadvertently caused security to lapse, or at least failed to promote further developments.

Recent natural occurrences such as earthquakes and tsunamis have demonstrated their potential to affect large swaths of the country. A Katrina-sized hurricane in the mid-Atlantic region would affect a far greater population. The Northeast blackout in 2003 demonstrated how quickly a single event cascades through an inability to control fragile networks. However, the drive for efficiency and cost savings has made investment in modern control systems a low priority. The lack of system-wide automation and monitoring abilities has hindered the isolation and recovery from failures. Individual systems have been connected to allow supply from many suppliers, but these systems are insufficient to provide effective monitoring and timely response.

A deliberate attack on our grid is a tremendous concern and has been for decades (Lovins & Lovins, 1983). A determined attacker with a basic understanding of electrical systems, simple observation, and the Internet, has adequate tools to mount a devastating attack. "A coordinated attack on a selected set of key points in the system could result in a long-term, multi-state blackout. While power might be restored in parts of the region within a matter of days or weeks, acute shortages could mandate rolling blackouts for as long as several years (NRC, p.181)."

The events of 9/11 demonstrated that terrorists can possess the necessary level of deliberate and sophisticated planning to threaten the electrical grid. Devastating effects could easily be achieved through coordinated terrorists with car bombs driven into poorly protected substations, or simply by rifle fire into critical components.

A cyber attack could achieve longer-lasting and more widespread effects. Viruses have already affected one nuclear power plant's operations. Other attacks have also occurred: in 2000 a discontented consultant, rejected for a job at a water treatment plant in Australia, remotely hacked into a sewage treatment system and released 264,000 gallons of raw sewage into rivers and parks. "Some weaknesses, already well known to hackers, foreign governments and, most likely, jihadists, have been exposed in two areas: the Domain Name System that VeriSign oversees and the Border Gateway Protocol" (Lenzner & Vardi).

Damage, disruption, and financial loss can occur quickly. "Utilities have traditionally defined an outage as an interruption of five minutes or more, but digital hardware cannot tolerate power interruptions that last more than milliseconds" (Lapierre, p. 19). This is one reason that distributed power generation and transmission has received so much attention and why industry

began investing in reliable, smooth, stable off-grid power long before 9/11.

Changing the infrastructure will be costly, but the end-result will be positive for the economy. Consider the effect of making personal computers and the Internet ubiquitous in the workplace: the costs were clearly offset by gains in productivity. There is good reason to expect similar gains from a distributed and resilient energy supply system.

There is no “silver bullet” solution. Like many complex problems, the best approach is to give all stakeholders a role in developing a solution. One possible solution involves the formation of a non-profit organization, the Electrical Security Strategy Company (ESSC), representing all stakeholders from government and industry, to develop long-range plans and propose resources to secure the grid. Plans would be presented to the Department of Homeland Security (DHS) for review, be subject to Congressional review and funding, and require an all or nothing vote (similar to the Base Realignment and Closure process) to minimize pork barrel and earmark spending.

Securing the nation’s electrical grid is an enormous problem and has been studied for many years. What follows is a proposed list of how to get started:

- Review the grid vulnerability modeling work that has been done by DoD and DoE. Compile the results of common elements, and prioritize the vulnerabilities. This will provide a starting point of commonly held items, backed up with data and analysis.
- Develop a multi-year plan for distributed power grid configuration.
- Protect the grid from cyber-attack in the immediate future. Other than damage from natural forces, cyber-attack poses the most imminent threat.
- Use the bully pulpit to inspire action. Memories of the 2003 blackout are fading fast; crisis can compel change, and lessons learned should not be forgotten! Government and industry leaders should educate and inform the public and policy makers about the grid’s fragility and the costs of inaction, and not just the expense of upgrading systems. Leadership must not shrink from the need to act in order to avert a bigger crisis.

Conclusion

The nation’s electrical grid is clearly fragile, and the threat of interruption or destruction is real. Nature, age, and malice all pose long term and costly threats. Short-duration non-malicious interruptions have cost the economy tens of billions of dollars; that alone should provide impetus to make the grid more secure. Industry and government must act before the threat manifests more seriously. An effective partnership would provide a resourced and measurable plan for securing the grid.

(CDR Robert Bodvake, USN)

Distributed Power Generation

There is no panacea to managing the strain on our electrical system, but an array of ideas centering on distributed power generation may present the best answer. A new kind of electric system is possible—one that is decentralized, resilient, and focused on the efficient delivery of services such as lighting and cooling. Such a system would take advantage of the nation's potentially abundant supply of renewable energy sources, reduce strain on the electric grid through conservation and efficiency, and encourage the development of flexible and reliable small-scale distributed generation systems (USPIRG). In effect, a “trilemma” of economics, politics, and technology circumscribes the development of the electricity sector (EPRI, 2003). To be successful, this transformation must be grounded in a series of public and private policies that will seek to stabilize electricity markets, protect the environment, educate and empower the

consumer, and unleash innovation (EPRI, 2003).

Economic Solutions: Increase Efficiency, Reduce Demand and Provide Incentives

Efficiency is the fastest and cheapest way to eliminate the most vulnerable energy supplies (e.g. Persian Gulf oil), making their failure inconsequential (Lovins, 1997). Analysts estimate that the US could reduce commercial and residential electricity use by one percent within a single year by implementing proven efficiency strategies. The challenge is to get utilities to offer incentives for customers to use electricity more efficiently.

Political Solutions: Restore Accountability

To ensure the continued reliability of the interconnected transmission grid, reliability rules must be made mandatory and enforced, and they should be applied fairly to all electric industry participants. However, the role of government should be limited, and instead of assuming a direct responsibility for service, government should assure necessary incentives and penalties to maintain industry accountability for the obligation to provide service.

Technology Solutions: Shift to Clean Sources of Local Power

Clean alternatives such as wind and solar power, combined heat and power systems, and fuel cells can reduce the demand on centralized fossil and nuclear power plants and reduce strain on the grid by providing local power to communities. Federal and state officials should adopt renewable energy standards requiring the generation of a significant percent of America's power from renewable sources in the near-term, set pollution limits for generators of electricity, and allow local power producers to sell their excess electricity back into the grid through the use of "net metering" (USPIRG). The government should provide long-term incentives for builders and homeowners to add emerging technologies to homes such as solar water heaters, photovoltaic grids and wind generators, in order to reduce grid reliance and increase independence.

Distributed Power Solution

The DoE defines distributed generation (DG) as "a variety of small, modular power-generating technologies that are used to improve the operation of the local electricity delivery system. These systems can be combined with energy storage and power management and are usually, but not always, connected to an electricity distribution grid." This means smaller power generation plants, including solar and biodiesel, located closer to homes and businesses where the power will be used. This reduces energy lost in transmission and creates what Gordes calls "microgrids." Gordes says that DG is not only an excellent opportunity to integrate renewable technologies, but a redundant, separately administered power system would lessen the effect of a terrorist attack on the system by decentralizing power. The best solution to blackout problems may not be to expand our national grid, but to focus on reducing grid demand by removing electric power loads through incentives for installing DG units (Gover).

The economic benefits of distributed power include the reduction of losses in the electricity transmission system, a deferred need for transmission system upgrades, and enhanced reliability (Morris). An inherently resilient system should include many relatively small, fine-grained elements dispersed in space, each having a low failure cost. Components should be organized so that each element can interconnect with the rest at will but also stand alone, and each successive level is not affected by failures or substitutions at subordinate levels. Components should be understandable, maintainable, and reproducible at a variety of scales (Lovins & Lovins, 1982). Dave Sjoding, manager of the Northwest Combined Heat and Power Application Center, where six states collaborate on DG projects that provide both heat and power said, "Distributed generation reduces transmission and distribution issues. Now the power is produced locally and used locally and you're not having to move it a huge distance." Regarding national security,

Sjoding said the benefit is obvious: "As you bring distributed power into the system, you ensure that all the eggs are not in one basket" (Mackenzie). (CAPT Edward Daum, USN)

A US Foreign Policy Strategy for Energy Security (International Perspective)

With less than 5% of the world's population, the US consumes 25% of its oil. To meet this disproportionate energy need it imports 66% of its total oil consumption. Policy makers must accept the bitter reality and impossibility of breaking current economic and security linkages to foreign oil for the near future. Energy security therefore is a foreign policy challenge.

The US should follow a four pronged strategy: ensuring supplies from current exporters by addressing the bilateral relations to ensure stability, increasing imports where possible mainly from contiguous countries, reducing the leverage of OPEC by coordinating with China and India and, begin to diversify suppliers. Several things can be done immediately to ensure a smooth and uninterrupted supply of oil from OPEC in the coming decades.

US foreign policy driven by the GWOT should remain cognizant that nine of the OPEC members are Muslim majority countries who face domestic popular pressures against the US if the latter's policies were perceived as anti-Muslim by the masses. Increases in imports from more reliable neighbours like Canada and Mexico must be gradually pursued. The strategy should be to engage OPEC, particularly Saudi Arabia and Venezuela, but without intervention and with as little interference as possible.

Sixty-six percent of the total US oil consumption is met through imports of which Saudi Arabia accounts for over 15%. American national interests in the area can be categorized into reduction and elimination of terrorist threat, ensuring security of oil supply at below market rates, and maintaining stability in the region. Of these interests, regional stability is crucial and directly contributes to the other two and therefore strategy should be driven by regional stability more than others.

Venezuela sells about 60% of its output to the US, accounting for 10% of American oil imports. The US should acknowledge that of its two primary concerns in Venezuela - instability and President Hugo Chavez, stability in the region should be the emphasis, as with the Middle East. US strategy with Chavez should focus on making disruption in supplies cost prohibitive for him. This can be done if the US enters in a formal energy cooperation agreement with China and India whose energy requirements and interest drive most of Chavez's rhetoric. Creation of a union of oil exporting countries of Latin America, such as the Western Hemisphere Energy Forum called for by Senator Lugar, would provide a useful mechanism for energy cooperation by including countries like Venezuela. Similarly, a migration agreement with Venezuela (and Mexico) could give the US additional leverage. Current debates in the US on immigration should also be viewed from the perspective of energy security.

A major thrust of American energy security policy should be to incorporate major consumers of energy into a global framework to enhance cooperation and reduce competition for energy. This can be furthered by sponsoring China and India for inclusion in the International Energy Agency (IEA). Such cooperation would reduce the OPEC's leverage, and enhance the so-called monopsony wedge. It is paramount for the US to cooperate with China and develop an energy security umbrella including common strategic reserves of oil, shared research and development, and common policies toward oil exporting countries. The recently introduced energy diplomacy and security act by Senator Lugar calling for a formal coordination agreement with China and India is a step in the right direction. These measures do not involve infrastructure development or excessive funding, and can be undertaken immediately. For such a strategy to

succeed; however, Chinese fears about India, real or perceived, need to be allayed and major US agreements with India must take into account China's concerns. If this does not happen, China would continue to manipulate major oil exporters to its advantage at the USA's expense.

(BG Ishfaq Ahmad, Pakistan Army)

Energy Supply – A European Union Perspective (International Perspective)

The European Commission defines security of supply as: “the ability to ensure that future essential energy needs can be met, both by means of adequate domestic recourses...or maintained as strategic reserves, and by calling upon accessible and stable external sources supplemented...by strategic stocks.” In 1996, the Trilateral Commission described three aspects of energy security: limiting vulnerability to disruption given rising dependence on imported oil from an unstable Middle East; the provision of adequate supply for rising demand at reasonable price; and energy related environmental changes. The European energy market is expanding and is increasingly dependent on supply. This supply faces several risks involving physical risk (creating permanent or temporary disruptions), economic risk (price volatility in the market), and socio-political risk (to include environmental concerns).

The physical risk to European energy supply involves the physical security of supply networks, particularly by terrorist action, and energy infrastructure investments to satisfy domestic consumption. The European Union (EU) requires common standards and requirements relating to energy distribution management systems, control of external interference, public awareness, emergency planning, inspection regimes, and transparent accident reporting.

Within Europe, disruptions of supply in the energy sector can also be caused by economic problems or political unrest, industrial conflicts (strikes), export restrictions or embargos by producer countries, and wider regional conflict with EU geopolitical implications. The resulting price volatility in the energy sector caused by these economic factors can lead to excessive investment when prices are artificially high, or inhibit investment in maintaining the current infrastructure or expanding infrastructure when prices are too low.

European nations remain concerned about energy supply because it can place their societies at a strategic disadvantage if energy is used as a foreign policy weapon as exercised by Russia in January 2006, when it cut off natural gas supplies to the Ukraine. Europe has taken measures to reduce supply risk by promoting energy efficiency through taxation and energy pricing policies that encourage more environmentally friendly energy use in the areas of transportation, energy production, and efficiencies in residential and commercial facilities.

To increase security and stability of supplies, the EU should focus on three policy areas. The first is one of prevention, whereby the EU engages at the regional and global level to minimize the political conditions creating supply disruptions. The second is that of deterrence, or the application of political and other pressures to keep producers from actually interrupting supplies for political reasons. Finally, containment, whereby threats to supply can be reduced through robust energy infrastructure, energy efficiency and alternative energy sources.

(Ms Inga Puikevskā, Latvia Ministry of Defense)

US Dependence on Oil Producers – Commentary (International Perspective)

The daily global demand for oil is around 80 million barrels, of which the US consumes 20.5 million. While the US produces around 8 million barrels per day, it still imports 55% of its consumption (EIA, 2005). Although Saudi Arabia accounts for 18.8% of the oil supply (the other major sources being Canada, Nigeria, Mexico and Venezuela), 70% of the world's existing

reserves (around 1000 billion barrels) are in the Middle East. With the decline in other reserves, the world will become increasingly dependent on the Middle East. Because oil is traded globally and is fungible, world oil consuming economies are vulnerable to and interested in the global security of all the suppliers. In his report on world oil supplies, Robert Hirsch shows that with peak production potentially 20 years or fewer away, the energy challenge is now more pressing than ever (Hirsch, 2005). With increasing demand from emerging countries, particularly China and India, some predict that world energy demand will rise by up to 60% by 2030 (EIA, 2004). The supplies of oil on which we depend are not limitless. We all must now consider oil and natural gas as limited resources.

The Advanced Energy Initiative for clean power plants and cars running on hydrogen, electricity, and ethanol with the goal of replacing more than 75% of Middle East oil imports by 2025 is a good challenge. It gives the US a national objective for the first time. But analysis of alternative fuels shows that these solutions will be mid- or long- term answers and will play only a minor role in reducing oil consumption in the near-term. In the US, as in many other Western countries, citizens would prefer to solve the dilemma simply by switching to alternative fuels, thus enabling them to maintain their current habits. However, even if alternative technologies are sought, these changes must be accompanied by significant changes on the demand-side patterns of US consumers. This requires increased public education on energy issues, modification of cultural habits and the political will to effect these changes.

Transportation accounts for 2/3 of US oil consumption (EIA, 2006c); the other third is mainly used by industries, and relatively small portion for commercial or domestic heating. The US consumes 8.5 million barrels per day to fuel 130 million cars and 80 million light trucks (vans, pick-ups and SUVs), which corresponds to about two gallons a day for each vehicle. As the US faces increasing high fuel prices, this is crucial information that should be communicated on a regular basis to the American people. When taken in the aggregate, individual efforts to reduce fuel consumption through the use of alternative fuel vehicles and changes in driving and commuting habits will have a significant impact on reducing US oil consumption and thus contribute not only to US security, but global security as well. The challenge will be on how to use the American sense of patriotism as a forcing function to reduce the consumption of oil.

(COL Pascal Buret, French Ministry of Defense, DGA)

CONCLUSION

Terrorist attacks, political instability in oil-rich states, and natural disasters have generated increased gas prices. This has heightened public awareness that our economic and national security depend on our ability to meet the nation's energy needs. As the Energy Industry Study examined our energy supply and infrastructure, we identified several key areas of vulnerability as well as some potential ways these vulnerabilities might be mitigated. It will take decades to reduce the vulnerability created by our dependence on imported oil. These issues are not new, but thus far, several factors have presented barriers to effective solutions.

Most experts agree the key to energy security is diversity, greater capacity, and decreased consumption. Market forces tend toward the use of inexpensive fossil fuels such as oil, natural gas, and coal. While clean coal technology is advancing rapidly, market economics do not currently favor its use. Currently alternative and renewable fuels represent only a small percentage of our total energy consumption. Until the cost of fossil fuels increase, large scale use of these alternative fuels will not become economically viable without government intervention.

Technology development required to diversify our energy portfolio has been hindered by a lack of unity of effort among government agencies, industry, and academia. Regulatory inconsistencies generate uncertainty that stifles industry's capital investment in critical infrastructure. Government policy has only been partially successful due to inadequate resourcing and lack of public awareness. In order to generate the synergy necessary to achieve energy security, a single lead agent or apolitical commission should be appointed to champion energy issues.

In addition, the US continues to emphasize energy solutions directed at increasing supply without adequate efforts to reduce demand. For example, mass transit is not widely accepted in all major urban areas and Americans continue to favor large cars and houses. Unless energy prices continue to increase, consumption patterns are unlikely to change. However, increased public awareness, perhaps spurred by widely-publicized conservation goals would be helpful. Also, CAFE standards, which have successfully spurred increased gas efficiency in automobiles, should be expanded to SUVs and other vehicles.

Finally, it is important to understand that our security is also tied to the energy security of our allies, and because energy resources are traded in a global market, it is impossible to isolate ourselves from growing global demand. For example, global economic growth in (e.g. China, India, etc.) will create increasing price pressure in the future. As we examined the energy sector in Australia, we recognized that they faced many of the same issues as the US. As we work to address our energy security needs, we must work together with the international community in order to find global solutions to what is very much a global problem.

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