AIR FORCE FELLOWS

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DEPARTMENT OF DEFENSE ENERGY STRATEGY

TEACHING AN OLD DOG NEW TRICKS

GREGORY J. LENGYEL
COLONEL, USAF

10

Brig Gen Kenneth Newton Walker

Kenneth Walker enlisted at Denver, Colorado, on 15 December 1917. He took flying training at Mather Field, California, getting his commission and wings in November 1918.

After a tour in the Philippines, he returned to Langley Field, Virginia, in February 1925 with a subsequent assignment in December 1928 to attend the Air Corps Tactical School. Retained on the faculty as a bombardment instructor, Walker became the epitome of the strategic thinkers at the school and coined the revolutionary airpower "creed of the bomber": "A well-planned, well-organized and well-flown air force attack will constitute an offensive that cannot be stopped."

Following attendance at the Command and General Staff School at Fort Leavenworth, Kansas, in 1933 and promotion to major, he served for three years at Hamilton Field, California, and another three years at Luke Field, Ford Island, and Wheeler Field, Hawaii. Walker returned to the United States in January 1941 as assistant chief of the Plans Division for the chief of the Air Corps in Washington, DC.

He was promoted to lieutenant colonel in July 1941 and colonel in March 1942. During this time, when he worked in the Operations Division of the War Department General Staff, he coauthored the air-campaign strategy known as Air War Plans Division—Plan 1, the plan for organizing, equipping, deploying, and employing the Army Air Forces to defeat Germany and Japan should the United States become embroiled in war. The authors completed this monumental undertaking in less than one month, just before Japan attacked Pearl Harbor—and the United States was, in fact, at war.

In June 1942, he was promoted to brigadier general and assigned by Gen George Kenney as commander of Fifth Air Force's Bomber Command. In this capacity, he repeatedly accompanied his B-24 and B-17 units on bombing missions deep into enemy-held territory. Learning firsthand about combat conditions, he developed a highly efficient technique for bombing when aircraft faced opposition by enemy fighter planes and antiaircraft fire.

General Walker was killed in action on 5 January 1943 while leading a bombing mission over Rabaul, New Britain—the hottest target in the theater. He was awarded the Medal of Honor. Its citation, in part, reads, "In the face of extremely heavy anti aircraft fire and determined opposition by enemy fighters, General Walker led an effective daylight bombing attack against shipping in the harbor at Rabaul, which resulted in direct hits on nine enemy vessels. During this action, his airplane was disabled and forced down by the attack of an overwhelming number of enemy fighters. He displayed conspicuous leadership above and beyond the call of duty involving personal valor and intrepidity at an extreme hazard to life." Walker is credited with being one of the men who built an organization that became the US Air Force.

Cut along dotted line

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Department of Defense Energy Strategy

Lengyel

Teaching an Old Dog New Tricks

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AIR FORCE FELLOWS

Department of Defense Energy Strategy

Teaching an Old Dog New Tricks

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Air Force Fellows

Since 1958, the Air Force has assigned a small number of carefully chosen, experienced officers to serve one-year tours at distinguished civilian institutions studying national security policy and strategy. Beginning with the 1994 academic year, these programs were accorded in-residence credit as part of professional military education at senior service schools. In 2003 these fellowships assumed senior developmental education (SDE), force development credit for eligible officers.

The SDE-level Air Force Fellows serve as visiting military ambassadors to their centers, devoting effort to expanding their colleagues' understanding of defense matters. As such, candidates for SDE-level fellowships have a broad knowledge of key Department of Defense (DOD) and Air Force issues. SDE-level fellows perform outreach by their presence and voice in sponsoring institutions. They are expected to provide advice as well as promote and explain Air Force and DOD policies, programs, and military-doctrine strategy to nationally recognized scholars, foreign dignitaries, and leading policy analysts. The AF Fellows also gain valuable perspectives from the exchange of ideas with these civilian leaders. SDE-level fellows are expected to apprise appropriate Air Force agencies of significant developments and emerging views on defense as well as economic and foreign policy issues within their centers. Each fellow is expected to use the unique access she or he has as grounds for research and writing on important national security issues. The SDE AF Fellows include the National Defense Fellows, the RAND Fellows, the National Security Fellows, and the Secretary of Defense Corporate Fellows. In addition, the Air Force Fellows program supports a post-SDE military fellow at the Council on Foreign Relations.

On the level of intermediate developmental education, the chief of staff approved several AF Fellowships focused on career broadening for Air Force majors. The Air Force Legislative

Fellows program was established in April 1995, with the Foreign Policy Fellowship and Defense Advanced Research Projects Agency Fellowship coming under the AF Fellows program in 2003. In 2004 the AF Fellows also assumed responsibility for the National Laboratories Technologies Fellows.

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Foreword

In *Department of Defense Energy Strategy: Teaching an Old Dog New Tricks,* Col Gregory J. Lengyel, United States Air Force (USAF), takes a comprehensive look at our national energy problems from a perspective unique to the Department of Defense (DOD). From his fictional opening implying that conflicts of the future could revolve around volatile world energy markets to his recommendations on creating and implementing a DOD energy strategy for improved energy security, the reader should find this book both thought provoking and informative.

The author begins by introducing our national and military addiction to vast amounts of energy. He adeptly points out that we have created the world's mightiest military but historically have not considered energy to be a critical component of the war-planning process. His discussion of the burdens associated with our energy consumption not only identifies the cost of energy as a commodity but the often overlooked cost of infrastructure, personnel, transportation, and delivery of our energy requirements.

Colonel Lengyel also identifies key vulnerabilities caused by our energy dependence: potential oil and electricity supply disruptions due to terrorism, sabotage, physical and cyber attack, and infrastructure failure. Additionally, he highlights areas where our dependence on imported energy creates foreign policy vulnerabilities.

In sum, Colonel Lengyel offers an analysis of current DOD energy strategy and proposes a strategy for improved energy security and an implementation plan. He highlights numerous USAF initiatives as a model for the DOD to pursue, such as bases operating on 100 percent renewable energy, Air Force Smart Operations 21 (AFSO 21) fuel savings processes, culture change, and leading the way in synthetic fuel testing and certification.

Our collective efforts to reduce energy demand and increase supply will provide the military greater sovereign options to protect our country in the future. I recommend this book to anyone who wishes to learn more about DOD energy security issues and potential solutions.

Michael W. Wynne
Secretary of the Air Force

About the Author

Col Gregory J. Lengyel

Col Gregory J. Lengyel is the commander, Combined Joint Special Operations Air Component, for United States Central Command. He is currently engaged in combat in Operations Iraqi/Enduring Freedom.

Colonel Lengyel graduated from Texas A&M University in 1985, earning his commission as a distinguished graduate in the Reserve Officer Training Corps. He is a command pilot with more than 3,700 flight hours in the UH-1H, UH-1N, TH-53A, MH-53J, and MH-53M. He is also a graduate of the US Marine Corps Weapons and Tactics Instructor course. Colonel Lengyel has served in several operational flying and staff assignments, including commander of the 21st Special Operations Squadron while flying MH-53M Pave Low IV helicopters in Operation Iraqi Freedom. He was also military assistant to the secretary of defense, Hon. Donald H. Rumsfeld, while he was assigned to the Pentagon.

Colonel Lengyel wrote this paper as part of the Air Force Fellows program while assigned as a National Defense Fellow at the Brookings Institution in Washington, DC. He is married to the love of his life, the former Diane Parman of Omak, Washington. Their pride and joy are children: Daniel, 15, and Matthew, 13. They aslo have a yellow Labrador retriever, named Duke.

Abstract

The United States has a national security problem that involves energy security, and the Department of Defense (DOD) has a unique interest in this problem. The United States imports 26 percent of its total energy supply and 56 percent of its oil. The DOD is the largest single consumer of energy in the United States, and energy is the key enabler of United States (US) military combat power. Huge energy consumption, increased competition for limited energy supplies, ever-increasing energy costs, and no comprehensive energy strategy or oversight of energy issues in the DOD have created vulnerabilities. These include potential fuel and electricity supply disruptions and foreign policy and economic vulnerability. The DOD needs a comprehensive energy strategy and an organizational structure to implement a strategy to improve national security by decreasing US dependence on foreign oil, ensure access to critical energy requirements, maintain or improve combat capability, promote research for future energy security, be fiscally responsible to the American taxpayer, and protect the environment. This strategy can be implemented through leadership and culture change, innovation and process efficiencies, reduced demand, and increased/diversified energy sources.

Preface

As an Air Force helicopter pilot, I have been an energy consumer for most of my career, and I am personally responsible for burning an estimated 1.1 million gallons of jet fuel during my 3,700 flight hours in UH-1N and MH-53J/M aircraft. I have often been forced to conserve fuel to accomplish specific missions but never because energy was an expensive or a finite resource.

In 2006, in response to changes in the international security environment, the Brookings Institution launched its Twenty-first Century Defense Initiative within the Foreign Policy Studies program with Peter W. Singer functioning as director, Michael O'Hanlon heading the research area, and visiting military fellows serving as core members. The initiative addressed some of the most critical issues facing leaders as they shaped defense and security policy in the coming century, including the future of war; the future of US defense needs and priorities; and the future of the US defense system.

In recent years, I have become increasingly interested in the growing problem of US dependence on imported oil. When selecting a research topic for this military fellowship, I could think of no more critical issue facing future military leaders than energy security.

I would like to thank my advisors from the Brookings Institution and Air University, Peter W. Singer and Larry G. Carter, for their guidance and assistance. Acknowledgements and thanks also go to Brookings research assistant, Ralph Wipfli, for faithfully forwarding energy-related materials.

Chapter 1

Introduction

Capt Steve Law was brushing his teeth when the phone rang. He'd been scheduled for an actual flying mission, a rare treat. Ninety percent of F-22 training was now conducted in simulators to save jet fuel, but one of the F-22 alert pilots was ill and he'd have to fill in for him. The Chinese would be flying a bomber past Honolulu in another one of their "friendship demonstrations," their tenth demonstration of 2020, and it was still only January.

It had been like this since Law's commissioning in the wake of the "9-11-2001" attacks, when Al-Qaeda had celebrated the 10-year anniversary of their first attacks with strikes at various subways across the United States and the bombings that took out the major Saudi oil production facilities. Captain Law remembers that day like it was yesterday. He was a senior at the University of Michigan and had already been accepted to Georgetown Law School. He was driving home in his Toyota plug-in hybrid to spend the weekend with his parents. His father was working as a Ford Motor Company executive. After many lean years under Chapter 11 bankruptcy protection, Ford had ceased operations in early 2001 and auctioned off all of its plants to Japanese auto companies. General Motors and Chrysler would suffer the same fate two years later. The American companies were simply overburdened with union health care costs, inefficient factories, and too far behind in developing energy-efficient electric vehicles. World oil demand had been outpacing supply for too long, and when crude oil prices reached $120 per barrel in 2009, the US automakers could not recover.

The year 2011 proved to be an important year. After eight years of occupation in Iraq, the last remaining US forces pulled out in June 2011, when Congress elimi-

nated funding for the war effort. The well-orchestrated Al-Qaeda attacks in September that year completely shut down Saudi Arabia's oil industry and crippled world energy markets. The year closed with Iranian military forces crossing the border into Kuwait and Iraq in December. They quickly seized all of the major oil production facilities and declared the Strait of Hormuz in the Persian Gulf as sovereign Iranian territory, closed to all other shipping. US military ground forces, their readiness and manning levels worn down from 10 years of constant fighting since 11 September 2001 (9/11), mobilized for a return to the Middle East. US air and naval forces immediately began attacking Iranian forces in Iraq and Kuwait. The going was tough but US forces started to make headway against the Iranians in the early weeks.

Everything changed when China got involved. In January of 2012, publicly blaming the war, the Chinese government tried to collect on their holdings of almost $1 trillion in US debt. The US government defaulted on payment and the value of the US dollar plummeted. The Euro became the main global currency. The collection though turned out to be a setup for something even bigger. In March of 2012, with absolutely no warning, the Chinese destroyed 70 percent of the US intelligence satellites in low-Earth orbits, took down much of the US electrical grid through computer hacking, and deployed over 3,000 fighter aircraft to Iran. It was later revealed that a bargain had been made for the support in exchange for exclusive buying rights to Iranian-controlled oil.

Wave after wave of attack struck at US forces. By June 2012, four of the 11 US aircraft carriers were destroyed and three more had been damaged; and 14 of the existing 21 USAF B-2 bombers were shot down. USAF pilots in the venerable F-22 had achieved a remarkable 19:1 kill ratio; but by August 2012, after shooting down 1,745 Chinese and Iranian fighters, they had gone from a force of 144 deployed aircraft to only 52. Other US *fighters had a clear qualitative advantage and performed admirably, but they were similarly overwhelmed by waves of enemy aircraft. Most importantly, fuel shortages began to cripple the United States. The forces in the field and units back home were almost immobile due to rationing, and the continued hackers' attacks on electrical grids made power a strategic commodity. Many units had been simply stranded in place. With the United States and China on the brink of a nuclear exchange, and after Chinese naval and air activity began near the Atlantic and Pacific coasts of the United States, a cease-fire was declared on 17 August 2012. All remaining US forces returned from the Middle East to defend the homeland, and much of East Asia was abandoned to the Chinese.*

More than the oddity of watching live Internet videos of troops in action and the subsequent Monday-morning quarterbacking on the blogs, Law recalled the economic chaos of that period. Life in the United States had changed forever. Even now, eight years after the war, the gross domestic product was still only at 60 percent of 2012 levels. The price of crude oil skyrocketed to 190 Euros per barrel and, with the weak dollar, became unaffordable to most Americans. The whole of the US airline industry went under in 2013, and few Americans could afford to fly on foreign-owned airlines. The US government nationalized domestic oil reserves, seized Latin American fields, and strictly rationed fuel to American consumers, with priority going to the government. But it was not enough. Were it not for the economic aid the Europeans still sent the United States, things would have been much more devastating. Many of Law's fellow officers grumbled that NATO was now profiting from the war it had sat out; but then again, beggars now could not be choosers. Many of the news stories compared it to the Great Depression. It seemed odd to Law that his generation would be going through just what his great-grandparents had. So much for progress.

> *As he drove past the front gate and saw the wind turbines set up on the parade grounds and solar panels lining the barracks building roofs, Law recalled how strange the old attitudes had been towards energy. Back when he was in high school, people had started to talk about the importance of energy, what with the rising gas prices, shortages after Hurricane Katrina, and then President Bush's description of an "energy addiction problem." Even the military had dabbled in various energy efforts, such as researching a coal-based liquid synthetic fuel and making a few bases more efficient. But, as usually happens, they had all waited for the crisis to hit its worst before they had developed a true strategy and the institutions to make it happen on a scale that mattered. It was too bad. Captain Law would like to have been in a world where he could actually fly his jet more often.*
>
> —Col Gregory J. Lengyel

The United States (US) has a national security problem that involves energy security in which the Department of Defense (DOD) has a unique interest. Energy is the lifeblood of the US economy, and dependence on imported energy is a looming national crisis. Cheap and abundant energy has been the historical norm for American consumers and war fighters. To most Americans, energy is taken for granted. Electricity is as much a part of daily life as breathing air and drinking water. Electricity powers our lights, alarm clocks, coffee pots, toasters, and heating, ventilation, and air conditioning systems; MP3 players, computers, televisions, traffic lights, subway systems, air traffic control networks, and industrial plants; and drives almost every other facet of daily life in the twenty-first century. It has been that way for almost 100 years. The US National Academy of Engineering ranks electrification as the number one engineering achievement of the twentieth century.[1]

The attention of much of American society is focused on individual mobility, extensive road networks, and large parking lots. The United States has more cars than registered drivers, and with a few notable exceptions, fuel has remained affordable and plentiful. Fuel costs moved from the subconscious to the conscious after recent increases in the price of oil and subsequent gasoline prices that reached $3 per gallon. For the most part, however, the increase in fuel prices has done little to reduce consumption.

The United States imports 26 percent of its total energy supply and 56 percent of the oil it consumes.[2] The DOD is the single largest consumer of energy in the United States.[3] The United States has built the mightiest military in world history but has done so with little regard to the huge burden that comes with an insatiable appetite for energy.

The DOD energy issues cannot be viewed in isolation. They are a subset of the larger national problem. Reducing dependence on imported energy is a critical national issue that must be addressed immediately.

First, the DOD needs to recognize the problem from a military perspective: energy is the key enabler of US military combat power. That combat power requires a huge consumption of mostly imported petroleum-based fuels. It also creates a command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR) structure that is dependent on a civilian electrical grid and rising costs to support the military's energy needs. Blatantly absent is a comprehensive strategy for an energy or organizational structure to implement an energy strategy.

Second, the DOD must recognize that energy dependence makes the military vulnerable in several ways. The DOD operations require assured access to large amounts of fuel for combat platforms. They also require electricity for DOD installations from a fragile and vulnerable electrical grid. Recent cost increases and higher projected costs take defense dollars from other key budgeted areas. Energy requirements are directly related to combat effectiveness, and the infrastructure required to transport and distribute energy to the battlefield is extremely expensive and diverts resources from combat initiatives. Combat forces are limited by a tether of fuel that needs to be lengthened.

Third, the DOD has long operated under the assumption that energy is cheap and plentiful; therefore, energy has not been managed like other combat enablers, including intelligence, acquisition, and logistics. This trend must end. Present DOD fuel costs represent approximately a 2.5 percent to 3 percent fraction of the national defense budget. That percentage may seem small, but in a fiscally constrained wartime environment where DOD and service budgets already have been cut and cut again, every dollar already is committed. The forecast calls for more of the same. An already huge national debt, federal budget deficits, a looming fiscal storm of rising national health care costs, and a potential social security crisis make fiscally constrained times appear permanent for the US government.

Fourth, the DOD must have a long-term energy strategy and an energy chain of command based on a comprehensive national energy strategy and a long-term vision of energy security to cover 50 years from now and beyond. Ideally, America will reach a clean, carbon-neutral, domestically controlled, abundant, and affordable energy solution. No one really knows which technology or energy source will provide the fork in the road away from a largely petroleum-dependent economy and military.

The DOD's energy strategy also must examine what can be done today and for the next 20 years to use energy more efficiently, use more environmentally friendly forms of energy, diversify energy sources, increase physical security, and assure access to needed energy. This near-term strategy will buy time for research and technology to help America reach the long-term vision. This paper focuses on the more near-term vision for the next 20 years.

In simple terms, DOD energy use can be divided into two main categories: petroleum-based fuel for mobility platforms and infrastructure energy (electricity and natural gas) supporting installations and facilities. The vast majority of DOD energy consumption, some 74 percent of total energy cost, supports mobility platforms, including aircraft, ships, and ground vehicles. Aviation fuel alone accounts for 58 percent of the total DOD energy cost. Buildings and facilities account for 22 percent of DOD energy cost.[4] If the DOD wants to save energy, it should look first at mobility platforms (particularly aircraft) and buildings.

This paper focuses primarily on those two energy categories. Although modern technology has created a growing demand to power electrical devices carried by the individual war fighter, this paper does not address those demands.

Chapter 2 discusses the high and growing demand for energy, the true cost of fuel in dollars, the force structure and combat capability, the limited supply and increased competition for limited energy resources, and the current energy strategy of the DOD.

Chapter 3 examines the implications of the energy problems of the DOD. These include vulnerabilities in fuel and electricity supplies and foreign policy and economic vulnerabilities.

Chapter 4 addresses the ongoing and needed actions required for the DOD to improve energy security through the creation of an energy strategy and an associated organization to implement the strategy through reduced demand, increased supply, diversification of energy sources, improved physical security, and more efficient and environmentally responsible energy use.

Chapter 5, the last chapter, reviews the main points of the paper and provides concluding remarks.

Notes

(Notes for this chapter and the following chapters appear in shortened form. For full details, see the appropriate entries in the bibliography.)

1. National Academy of Engineering, "Greatest Engineering Achievements of the 20th Century."
2. Fournier and Westervelt, *Energy Trends and Their Implications*, iv.
3. House, *Hearings before the Subcommittee on Terrorism*, 4.
4. Ibid.

Chapter 2

US Energy Problems

It is difficult to appreciate the scale in which energy is consumed. World consumption of oil averages 82.5 million barrels each day, enough to fill a swimming pool measuring approximately 1-mile long by 1-mile wide and 17 feet deep or the equivalent of 5,347 Olympic-sized swimming pools.[1] The United States consumes roughly 25 percent (20.7 million barrels) of those 82.5 million barrels,[2] with the government consuming roughly 1.9 percent and the Department of Defense (DOD) accounting for 93 percent of government use (fig. 1).[3]

As the single largest consumer of energy in the United States, the DOD uses 4.6 billion gallons of fuel annually or an average of 12.6 million gallons of fuel each day.[4] An Army heavy division may use 20 to 40 times the daily tons of fuel (about 600,000

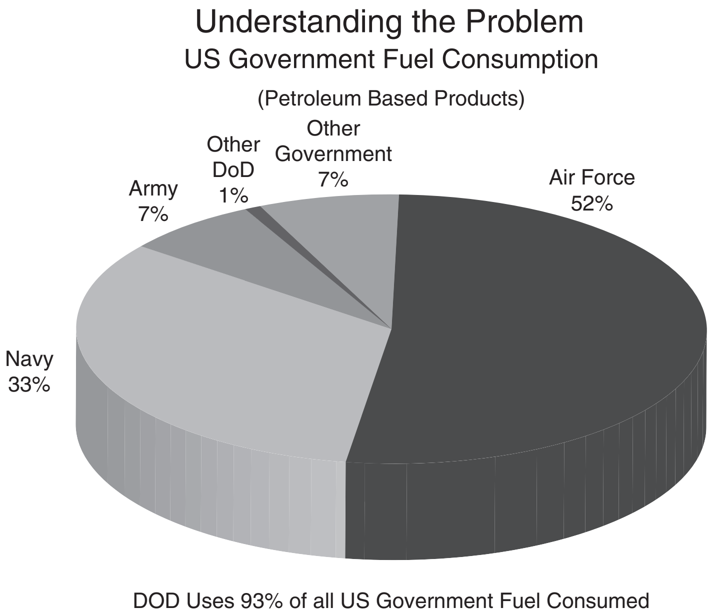


Figure 1. Fuel consumption. (Reprinted from Chris DiPetto, "Energy Efficiency for Tactical Systems" [PowerPoint presentation to 2006 PEO/SYSCOM Commanders' Conference].)

gallons each day) as it uses ammunition.[5] According to the *2005 CIA World Fact Book*, the DOD ranks 34th in the world as a country in average daily oil use, coming in just behind Iraq and just ahead of Sweden.

In fiscal year (FY) 2006, the DOD used almost 30 million megawatt hours (MWH) of electricity at a cost of almost $2.2 billion,[6] with almost 100 percent of electricity supplied to DOD installations from the civilian market or electric grid. South Dakota and Idaho consumed the same amount of energy as the DOD, 30,764,000 MWHs,[7] which is enough electricity to power 2,665,245 average-sized American homes.[8] If the DOD were a country, it would rank 58th worldwide regarding electricity consumption, using slightly less than Denmark and slightly more than Syria.[9]

True Cost of Fuel

Fuel does not come cheap. The DOD spent approximately $13.55 billion on energy as a commodity in FY 2006. Of that amount, the DOD spent roughly $10 billion on mobility fuels and $3.5 billion on facilities and infrastructure. A $10 per barrel increase in the cost of fuel increases the DOD operating costs by roughly $1.3 billion each year,[10] which roughly equals the entire 2007 procurement budget for the United States Marine Corps.[11]

The numbers alone are staggering and are clearly increasing. The DOD bill for jet fuel in FY 2006 was $7.9 billion. This represents a 73 percent increase from the FY 2000 cost of $2.2 billion, with only a 12 percent increase in gallons consumed (largely attributable to the global war on terror). However, fuel costs for budgeting and resource planning have traditionally been based on the Defense Energy Support Center (DESC) standard price, which does not reflect the cost of the fuel logistics system required to deliver fuel to the war fighter. The standard price of fuel represents only a fraction of the true cost.

> A 2001 Defense Science Board study, *More Capable Warfighting through Reduced Fuel Burden*, found that the Air Force spent $4.4 billion to fuel aircraft over a 12-month period, $1.8 billion to purchase the fuel, and $2.6 billion to deliver it by way of ground or air refueling. Only 6 percent of the total fuel purchased was delivered by air refueling, yet air refueling accounted for 85 percent of the delivery costs. The Office of the

> Secretary of Defense (OSD) recently conducted a more in-depth study on the burdened cost of fuel to capture the cost perspective and the capital expenditure involved in building, operating, and maintaining the fuel logistics infrastructure required to deliver fuel. The study began with the DESC standard fuel prices for the most commonly used DOD tactical fuels. It added costs of delivery asset operations and support, asset depreciation, infrastructure operations and support, and other service/delivery-specific costs. The importance of the study lies more in the accounting methodology being developed than the actual numbers it produced, but the numbers are revealing, nonetheless.[12]

Amazingly, jet fuel purchased at $2.30 per gallon costs the Air Force more than $42 per gallon when delivered by way of air refueling and costs $2.79 per gallon for ground delivery. This purchase averages out to $6.36 per gallon total. Army and Navy average burdened fuel costs totaled $5.62 and $3.08 per gallon, respectively.[13]

A long-range Army helicopter resupply mission—traveling 600 kilometers with eight logistical supply aircraft and providing fuel at three separate staging areas en route—would result in fuel costs approaching $400 per gallon as delivered to the resupply aircraft when accounting for the cost of aircraft utilization and fuel used to establish the staging areas.[14] Force structure dedicated to fuel delivery is also expensive. The Army alone has approximately 20,000 active and 40,000 reserve soldiers in fuel-related jobs that cost around $3.2 billion each year.[15]

Dependence on fuel carries a high cost in combat capability, which is impossible to quantify in dollars. In the early stages of Operation Iraqi Freedom (OIF), US Air Force MH-53M Pave Low special operations helicopters originally planned to base in Southern Turkey were forced to leapfrog from Cyprus in the eastern Mediterranean Sea across Turkey to an airstrip in Northern Iraq after Turkey denied US basing rights. The MH-53s were tasked to support Army Special Forces flown in by way of MC-130s from Romania and to stand alert for combat search and rescue (CSAR) until dedicated CSAR assets would arrive weeks later. The helicopters air refueled before entering Iraq to top off their fuel tanks. For several days during the most intense fighting of OIF, the fuel in their tanks was the only fuel available to conduct missions until the nightly MC-130P Combat Shadow passed overhead to conduct an air-refueling resupply and to allow the Pave Lows to top off for the next 24-hour period. An

Army special operations support battalion impressively established fuel logistics support in only a few days, and the MC-130P tankers eventually co-located with the helicopters, but fuel was clearly the operational limitation early on.[16]

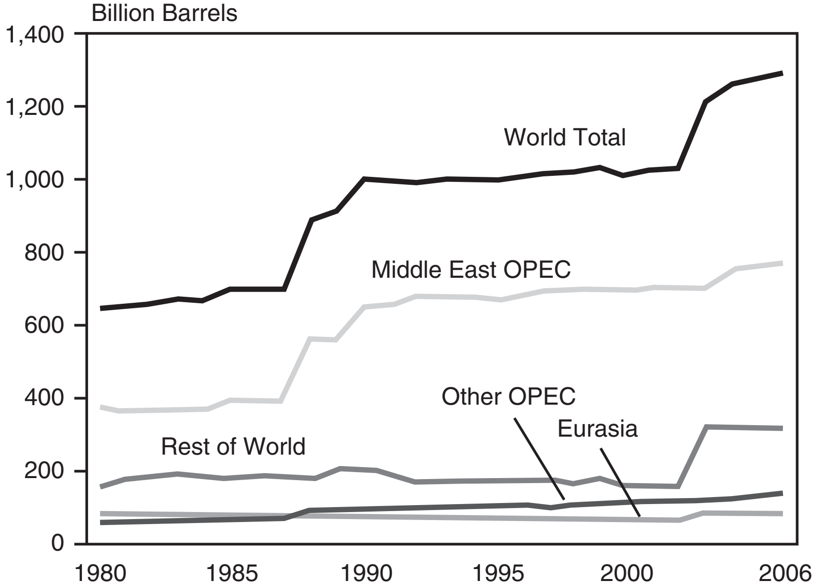
Ground units in OIF faced similar problems, as fuel represents more than 50 percent of the DOD logistics tonnage and more than 70 percent of the tonnage required to put the US Army into position for battle.[17] The pace of advance for some Army and Marine field units was so rapid that to maintain both the velocity and the operational tempo of their highly mobile forces located across a wide battle space, the subject of fuel was an ever-present consideration. Lt Gen James Mattis, commanding general of the First Marine Division during OIF, issued a post-combat experience challenge to the Department of the Navy research officials to "unleash us from the tether of fuel."[18]

Supply

The problem of high cost seems destined to worsen. Proven reserves of oil are generally taken to be those quantities that geological and engineering information indicates with reasonable certainty can be recovered from known reservoirs under existing economic and geological conditions. The historical trend for estimates of proven world oil reserves generally has moved upward, with new discoveries outpacing consumption (table 1). According to *Oil & Gas Journal*, as recent as January 2006, the world's proven oil reserves were estimated at 1,293 billion barrels or 15 billion barrels higher than the estimate for 2005.[19]

How long will 1,293 billion barrels of oil last? So many variables abound that any response is speculative. No one can gauge with certainty the scale of potential new oil discoveries, changes in consumption, or breakthroughs in technology that may occur. According to the Society of Petroleum Engineers, estimated proven reserves will supply the world with oil for approximately 44 years at current consumption rates.[20] However, a publication of the Department of Energy, Energy Information Administration (DOE/EIA), the *International Energy Outlook 2006*, estimates world oil demand will increase from 80 million barrels per day in 2003 to 98 million barrels per day in 2015

Table 1. World crude oil reserves, 1980–2006



Reprinted from DOE/EIA, *International Energy Outlook 2006*, 27.

and then to 118 million barrels per day in 2030. That's a 47 percent increase from 2003 to 2030. Much of the projected increase in oil consumption is attributed to strong economic growth in China and India.[21]

Global oil reserves are the source for the world oil market, but world oil-production capacity is the current limiting factor affecting supply in the global market. Excess production capacity represents the ability to surge production to make up for increased demand or reduced production elsewhere in the market. Demand hovering at or near supply with limited excess capacity characterizes a tight market. In the world oil market of 2007, excess capacity means political and economic influence.

The Persian Gulf contains 715 billion barrels of proven oil reserves, representing more than one-half (57 percent) of the world's oil reserves. Also, at the end of 2003, Persian Gulf countries maintained about 22.9 million barrels per day of oil-production capacity, or 32 percent of the world total. Perhaps even more significant, the Persian Gulf countries normally maintain almost all of the world's excess oil production capacity (fig. 2). As of early September 2004, excess world oil-production capacity was only about 0.5–1.0 million barrels per day, all located in Saudi Arabia.[22]

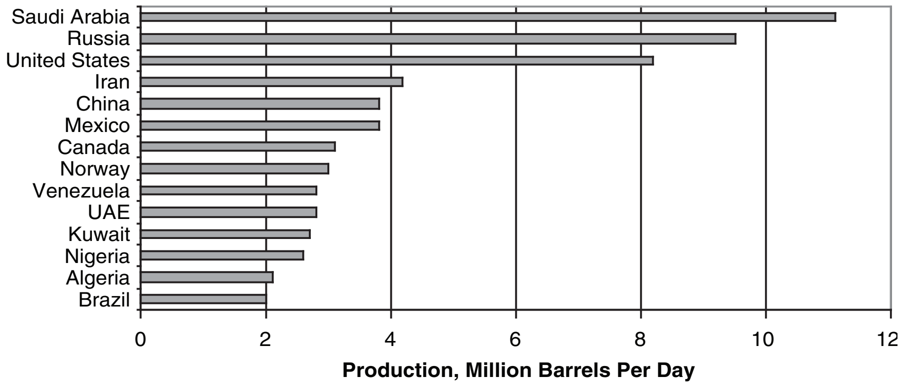


Figure 2. Top world oil producers 2005. (Data from DOE/EIA, "Top World Oil Producers." Graph was produced by the author.)

DOD's Current Energy Strategy

Despite current trends, the DOD's energy strategy remains ill defined, and no single individual or organization responsible for energy issues exists within the department. The DOD *Annual Energy Management Report* for FY 2006 lists the principal deputy undersecretary of defense (Acquisition, Technology, and Logistics) as the DOD senior energy official responsible for meeting the goals of the Energy Policy Act of 2005 and Executive Order (EO) 13123, *Greening the Government through Efficient Energy Management.*[23] However, this position has been vacant for several years and does not satisfy the need for a comprehensive senior energy official for the department.

This is not to say the DOD is unconcerned with energy issues. The OSD and the services have recently conducted or sponsored numerous studies focusing on energy, many of which have provided invaluable information for this paper: MITRE Corporation's JASON Project, *Reducing DOD Fossil Fuel*

Dependence (2006); Defense Science Board, *More Capable Warfighting through Reduced Fuel Burden* (2001), and the soon-to-be-released *Energy Strategy* (2006–7); Office of the Secretary of Defense, energy security integrated product team (2006); Air Force Scientific Advisory Board, *Technology Options for Improved Air Vehicle Fuel Efficiency* (2006); Navy Research Advisory Council, *Study on Future Fuels* (2005); Army Corps of Engineers, *Energy Trends and Their Implications for US Army Installations* (2005); and Defense Advanced Research Projects, *Petroleum-Free Military Workshop* (2005), to name a few. Common recommendations include making fuel efficiency a more significant factor in determining new mobility platforms (e.g., miles per gallon for ground vehicles, nautical miles/pound payload for aircraft and ships) and creating incentives for energy efficiency throughout the DOD. Additionally, none of the studies offered anything other than liquid hydrocarbons as the best fuel for DOD mobility platforms for at least the next 25 years.

Impressive groups of energy experts have produced many of these studies, but they are all either service-specific or temporary in nature, meaning the group of experts dispersed after writing the study's final report. The absence of a full-time energy advocate within the DOD leaves a void in follow-up actions to study recommendations or the creation of directive guidance on energy issues within the department.

The good news is that most of the needed energy expertise already exists in various functional areas of OSD and the services, and parts of a comprehensive energy strategy already are in place. The Air Force recently published an energy strategy that emphasized optimizing energy use, reducing demand, and expanding supply options. These issues will be targeted primarily through initiatives in aviation, infrastructure, and vehicles.[24]

The DOD already has an outstanding installations and facility energy management program, led by the deputy undersecretary of defense (DUSD) for Installations and Environment, that in many ways is a model for the federal government. DOD's posture is outlined in the following facility energy management policy statement.

> The Department of Defense (DOD) occupies over 620,000 buildings and structures worth $600 billion comprising more than 400 installations

> on 25 million acres in the United States and spent over $3.5 billion on facility energy consumption in Fiscal Year (FY) 2006. DOD is the largest single energy consumer in the Nation representing approximately 78% of the federal sector, and a significant (and sometimes the largest) energy user in many local metropolitan areas. Conserving energy and investing in energy reduction measures makes good business sense and allows limited resources to be applied to readiness and modernization. The Department has already reduced its facility energy consumption significantly; by FY 2005, the Department had already achieved a reduction in energy consumption by 28.3 percent as compared to a FY 1985 baseline. Due to the Energy Policy Act of 2005 in FY 2006, the baseline was reset to FY 2003. DOD achieved a 5.5 percent reduction in goal facilities for FY 2006. Despite this success, the Department must make greater strides in energy efficiency and consumption reduction in order to meet the Departmental vision of providing reliable and cost-effective utility services to the Warfighter. Dramatic fluctuations in the cost of energy significantly impact already constrained operating budgets, providing even greater incentives to conserve and seek ways to lower energy consumption. These include investments in cost-effective renewable energy sources, energy efficient construction designs, and aggregating bargaining power among regions and Services to get better energy deals.[25]

In November 2005 Phil Grone, the DUSD for Installations and Environment, published a memo to the services and directors of defense agencies to provide facility energy management goals consistent with current legislation, executive orders, and DOD direction, stating that "the Department of Defense will strive to modernize infrastructure, increase utility and energy conservation and demand reduction, and improve energy flexibility, thereby saving taxpayer dollars and reducing emissions that contribute to air pollution and global climate change."[26] The applicable goals from Grone's memo to the services included:

- Greenhouse Gases (GHG) Reduction: Through life-cycle cost-effective measures, each Defense component shall reduce its greenhouse gas emissions attributed to facility energy use by 30% by 2010 (compared to 1990 levels).
  [Note: Kyoto Protocol GHG reduction goal for the United States was 7%.]

- Reduce Energy: Through life-cycle cost-effective measures, each Defense component shall reduce energy consumption per gross square foot of its facilities.

- o All facilities: Reduce consumption by 2 percent/year relative to 2003 baseline.
- o Facility Energy Audits: Conduct energy and water audits at 10% of facilities each year.

- Renewable Energy Procurement: Each Defense component shall strive to expand the use of renewable energy within its facilities and in its activities by implementing renewable energy projects and by purchasing electricity from renewable sources. Renewable Goals (when life-cycle cost-effective):
  - o 3% of their total electricity demand in FY 2007–2009
  - o 5% in FY 2010–2012
  - o 7.5% in 2013
  - o 25% by 2025
- Petroleum Use: Through life-cycle cost-effective measures, each Defense Component shall reduce the use of petroleum within its facilities. Components may accomplish this reduction by switching to a less GHG-intensive, non-petroleum energy source, such as natural gas or renewable energy sources; by eliminating unnecessary fuel use; or by other appropriate methods.[27]

The $3.5 billion the DOD spent on facilities and infrastructure energy does have an oversight structure in place. By contrast, the $10 billion spent on fuel and the countless billions spent on force structure, fuel logistics, and research and acquisition does not have a parallel oversight structure. A comprehensive strategy, oversight, and energy advocate in the department must replace this deficiency.

Notes

1. The author's calculation shows that 82.5M bbl x 42 gal/bbl = 3.465B gal x 0.133680556ft^3/gal = 463,203,127 ft^3 = 5,280 ft x 5,280 ft x 16.6 ft.
2. Energy Information Administration, *International Energy Annual 2004*, table 12.
3. MITRE Corporation, *Reducing DOD Fossil Fuel Dependence*, 14.
4. Department of Defense, *FY 2006 Energy Management Data Report.*

5. MITRE Corporation, *Reducing DOD Fossil Fuel Dependence*, 13.

6. Department of Defense, *FY 2006 Energy Management Data Report,* tables 1-1, 1-2.

7. Energy Information Administration, *Electric Power Annual 2005,* 47.

8. According to EIA (http://tonto.eia.doe.gov/ask/electricity_faqs.asp#electricity_use_home), the average US home uses 938KWH of electricity monthly (accessed 20 March 2007).

9. See NationMaster.com, http://www.nationmaster.com/graph/ene_ele_con-energy-electricity-consumption#source (as derived from *CIA World Fact Book 2006*).

10. House, *Hearings before the Subcommittee on Terrorism,* 5.

11. House Resolution 5122, 109th Cong., 2d sess., 2006, sec. 102 (b).

12. Defense Science Board, *More Capable Warfighting,* 17.

13. Office of the Secretary of Defense, *Burdened Cost of Fuel.*

14. Defense Science Board, *More Capable Warfighting,* 19.

15. Ibid., 39.

16. Account by the author, 21st Special Operations Squadron commander (MH-53M), at the start of Operation Iraqi Freedom.

17. Defense Science Board, *More Capable Warfighting,* 4

18. Office of the Assistant Secretary of the Navy, *Future Fuels,* 3.

19. Energy Information Administration, *International Energy Outlook 2006,* 27.

20. Society of Petroleum Engineers, *How Much Oil and Natural Gas?*

21. Energy Information Administration, *International Energy Outlook 2006*, 25.

22. Energy Information Administration, Country Analysis Briefs, *Persian Gulf Oil and Gas Exports Fact Sheet*, http://www.eia.doe.gov/emeu/cabs/pgulf.html (accessed 20 February 2007).

23. Superseded by Executive Order 13423, *Strengthening Federal Environmental, Energy, and Transportation Management*, 26 January 2007.

24. Wynne, USAF Energy Forum.

25. Deputy Undersecretary of Defense (I&E) Facility Energy Management Policy Statement, www.acq.osd.mil/ie/irm/underEnergy/Energy%20Home/EnergyAboutPolicyStatement.htm (accessed 21 February 2007).

26. Grone to service secretaries, memorandum.

27. Ibid.

Chapter 3

Implications of the Problem—Vulnerability

> ***Vulnerability:*** *The susceptibility of a nation or military force to any action by any means through which its war potential or combat effectiveness may be reduced or its will to fight diminished.*
>
> ***Strategic vulnerability:*** *The susceptibility of vital instruments of national power to being seriously decreased or adversely changed by the application of actions within the capability of another nation [or non-state actor] to impose. Strategic vulnerability may pertain to political, geographic, economic, informational, scientific, sociological, or military factors.*
>
> —Joint Publication 1-02
> *DOD Dictionary of Military and Associated Terms*

US dependence on huge amounts of oil and electricity to power our economy and our military creates much vulnerability. It would not be wise to publish a detailed list of US vulnerabilities nor of its global energy critical infrastructure or key resources; however, it is no secret that vulnerabilities do exist. Terrorists or common vandals in either the United States or around the globe already have attempted all of the open-source referenced scenarios described later in this chapter.

Potential Oil Supply Disruptions

The National Research Council contends that "Our nation's dependence on imported oil leaves it dangerously vulnerable to attack. A single well-designed attack on the petroleum infrastructure in the Middle East could send oil to well over $100 per barrel and devastate the world's economy."[1] In addition, a recent Congressional Research Service report to Congress highlighted terrorists' emphasis on exploiting oil vulnerabilities:

> Al-Qaeda leaders' statements reveal sophisticated consideration of the economic and military vulnerabilities of the United States and its allies,

> particularly with regard to the role of Middle Eastern oil as "the basis of industry" in the global economy. Statements by Bin Laden and Al Zawahiri urging attacks on oil infrastructure and military supply lines could indicate a shift in Al-Qaeda's strategic and tactical planning in favor of a more protracted attritional conflict characterized by disruptive attacks on economic and critical energy production infrastructure. For example, in an interview reportedly conducted on or around the fourth anniversary of the September 11 terrorist attacks, Al Zawahiri urged "mujahidin [*sic*] to concentrate their campaigns on the Muslims' stolen oil" and to "not allow the thieves ruling [Muslim] countries to control this oil." Bin Laden has called for Muslim societies to become more self-sufficient economically and has urged Arab governments to preserve oil as "a great and important economic power for the coming Islamic state." Bin Laden also has described economic boycotts as "extremely effective" weapons.[2]

Instability and hostility towards the United States characterizes most of the oil-producing world. An oil-supply crisis no longer can be dismissed as a low-probability event. Hostile governments and terrorist organizations are well aware of America's and her allies' vulnerability and could use the oil supply as a strategic weapon to attack the United States. Oil-supply disruptions to the United States could happen in several ways, occurring singularly or combined. These include disruptions in world production by natural disaster, politically motivated embargo, terrorist attack on production and transmission infrastructure, or closure of world oil transit choke points. Any long-term disruption in oil supply to the United States is a national security issue that is unacceptable to the US government. However, most of these scenarios assume a major worldwide upheaval or political and other major changes in the primary oil-production regions of the world. These scenarios also go beyond the scope of this paper.

Additionally, if a catastrophe shuts down world oil flow, our government will ensure the DOD has priority access to domestic oil production and the 700–1,000 million barrels of oil in the strategic petroleum reserve. However, scenarios of supply disruptions to DOD installations through the US oil and gas transmission pipeline system or to deployed operational forces through fuel logistics distribution networks are not completely far fetched.

Almost one-half million miles of oil and gas transmission pipeline serve the United States. These pipelines are integral to the US energy supply and have vital links to such other critical infrastructure as power plants, airports, and military installations. The pipeline networks are widespread, running through remote and densely populated regions, and are vulnerable to accidents and terrorist attack. Roughly 160,000 miles of pipeline carry more than 75 percent of the nation's crude oil and around 60 percent of its refined petroleum products. The US natural gas pipeline network consists of about 210,000 miles of pipeline for field gathering and transmission nationwide.[3]

Pipelines are vulnerable to vandalism and terrorist attack with firearms, explosives, or other physical means. Some also may be vulnerable to cyberattack on computer control systems or vulnerable to an attack on the electric grid supplying power to them. Oil and gas pipelines have been targeted extensively by terrorists outside and within the United States. Rebels have targeted one oil pipeline in Colombia more than 600 times since 1995. In 1996, London police foiled a plot by the Irish Republican Army to bomb gas pipelines and other utilities. Since 9/11, federal warnings about al-Qaeda have specifically mentioned pipelines as possible targets. The 800-mile-long Trans Alaska Pipeline System (TAPS), which runs from Alaska's North Slope oil fields to the marine terminal in Valdez, Alaska, delivers nearly 17 percent of US domestic oil production. The TAPS already has been targeted numerous times, and in January 2006, federal authorities acknowledged a detailed posting on a Web site purportedly linked to al-Qaeda that encouraged attacks on US pipelines, especially TAPS, using weapons or explosives.[4]

Deployed operational forces are particularly vulnerable to supply disruptions. Fuel is delivered by convoy to Iraq from Jordan, Kuwait, and Turkey. In FY 2006, more than 156 million gallons of fuel were delivered to US/coalition forces in western Iraq. In the north, more than 103 million gallons of fuel were delivered through Turkey, utilizing 17,802 trucks that, if positioned end to end, would stretch from Washington, DC, to Wilmington, Delaware.[5] In July 2006, US Marine Corps major general Richard Zilmer, commander of the multinational force in western Iraq, submitted a priority request for a self-sustainable energy solution to reduce the number of fuel logistics convoys in Iraq that were increasingly vulnerable to attack (fig. 3).[6]

Figure 3. Fuel convoy traveling north into Iraq. (Photo reprinted from Marine Corps Air Ground Combat Center Web site, http://www.29palms.usmc.mil/.)

Potential Electricity Supply Disruptions

The DOD is just as dependent on electricity as is the average American consumer. Electricity powers our command, control, communications, computers, intelligence, surveillance, and reconnaissance networks; hospitals, lighting, heating and air conditioning, and thousands of other electronic devices. This great capability also has created a significant vulnerability. Without electricity, information would be dispatched with flags and bugle calls. To be sure, critical command and control nodes and other key facilities such as hospitals are supported by uninterrupted power supplies or diesel generators during short-term power interruptions. But what about the rest of the installation? How prepared is the department for a long-term power outage of six months or a year?

An understanding of some basic elements of our electric power distribution system is essential to see how vulnerable military installations are to electrical power disruption. In simple terms, the US electric grid is a network of networks, like a spider's web between power plants and consumers of electricity all over North America. The Web has many parts, and components required for delivery vary for different consumers. A typical electricity delivery scenario is described below.

First, power plants must generate electricity by converting such primary sources of energy as coal, natural gas, or geothermal or nuclear energy to electricity. An electric utility power station uses a turbine, engine, or other machines to drive an electric generator that coverts mechanical energy to electricity. These generation plants are becoming increasingly automated and are manipulated by supervisory control and data-acquisition systems that can be accessed through the Internet or by phone lines to increase efficiency through remote operations.[7]

In most cases, electricity flows from the generating facility to a step-up transmission substation, where the electricity passes through a transformer to increase the voltage. Higher voltage allows the electricity to travel efficiently and quickly through high-voltage transmission lines. High-voltage transmission lines deliver the electricity to a step-down transmission substation, where the electricity passes through another transformer to reduce the voltage for delivery to distribution substations.

Distribution substations are located closer to the electricity consumers and usually reduce the transmission voltage once again for use by end users. Electricity is then distributed through lower-voltage distribution lines and may pass through several other transformers before the electricity is actually used by consumers. These transformers are usually visible to consumers as the grey trash-barrel-sized cylinders on utility poles.

The combination of networks comprising the US electric grid is enormous and is often referred to as the world's biggest machine. More than 5,300 traditional electric utilities and non-utility power producers, operating more than 16,800 generators, net-produced 4,054,688,000 kilowatt hours of electricity for roughly 138 million customers in the United States in 2005.[8]

In the Unites States, more than 10,000 transmission substations and over 2,000 distribution substations exist. Substations are a critical component of the electric grid. A loss of only

4 percent of transmission substations would result in a 60-percent loss of connectivity.[9]

Sabotage, Physical, and Cyberattack

In *Brittle Power*, Amory B. Lovins and L. Hunter Lovins contend that

> the vulnerability of oil and gas terminals, processing plants, and pipelines is mirrored in central electric systems—only worse. The General Accounting Office recently audited the electrical security of a typical part of the United States; the audit found that sabotage of eight substations could black out the region, and that sabotage of only four could leave a city with no power for days and with rotating blackouts for a year.
>
> The roots of this vulnerability are not hard to find. To start with, electricity, though not itself flammable or explosive, cannot be readily stored. The electric grid provides no "pipeline inventory" of storage between generators and end users (unless they have provided local storage or backup at their own expense). Thus, in the event of supply or delivery failures, electric power must be rapidly rerouted to prevent widespread and instantaneous failure. This rerouting requires that generating and transmission capacity, switchgear, and control and communications capability be immediately available.[10]

Each of the major components of the power grid discussed in the previous section—power-generation facilities, transmission substations, transmission lines, and distribution substations—represents a physical vulnerability.

Of particular concern is the long lead times for replacing many of the critical components required to make the system work. For example, high-voltage transformers are generally reliable and expensive and often built overseas for specific installations; therefore, few spares are kept on hand. They can take from weeks to a year to replace.[11]

This vulnerability has captured the attention of Congress. As part of the Energy Policy Act of 2005, Congress tasked DOE to conduct a study and provide a report to the president and Congress on the benefits of using mobile transformers and mobile substations to restore power whenever a natural disaster, equipment failure, or acts of terrorism or war causes a power failure. An excerpt from the study is listed below to highlight the shortcoming in high-voltage transformers.

> Intentional disruptions such as sabotage could severely harm our Nation's electrical grid, and most substations are very vulnerable to at-

> tack. Substations are usually unmanned, remote, exposed, and have few physical barriers. Utilities rely more on redundancy of the grid for mitigation rather than on hardening of individual sites. The larger sites frequently have personnel and improved protections, but the consequences of loss of these large sites are comparatively greater as well. There are few options available for the replacement of a destroyed high-power transformer. While Mobile Transformer and Substation (MTS) Systems as large as 100 megavolt-amperes (MVA) exist, MTS systems are typically below 50 MVA in size, with high-side voltages not exceeding 230 kV [kilovolt]. High-power transformers, as described above, are greater than 100 MVA and can have high-side voltages of 345 kV or higher and at present cannot be backed up by MTS.[12]

Computer and remote control of power generation and transmission add both efficiency and vulnerability, causing Justin Blum to argue that "Hundreds of times a day, hackers try to slip past cyber-security into the network of Constellation Energy Group Inc., a Baltimore power company with customers around the country."[13] Thus far, the hackers have caused no serious damage to the power grid, but their efforts have heightened concerns that the system is vulnerable and that companies have failed to adequately insulate them against cyberattack. He adds that "The fear: In a worst-case scenario, terrorists or others could engineer an attack that sets off a widespread blackout and damages power plants, prolonging an outage."[14]

The Department of Energy's Idaho National Laboratory (INL) simulations show how a skilled hacker could cause serious problems by infiltrating a utility company's Internet-based business-management system to control utility operations. Once inside the company's network, the INL workers simulated cutting off the oil supply to a turbine generating electricity, which would have destroyed the equipment and shut down the plant.[15] Patrick H. Wood III, the chairman of the Federal Energy Regulatory Commission, was extremely concerned with the vulnerabilities highlighted by the outcome of the demonstration.[16]

Infrastructure Failure

In its report card for 2005, the American Society of Civil Engineers observed that "the US power transmission system is in urgent need of modernization. Growth in electricity demand and investment in new power plants has not been matched by investment in transmission facilities. Maintenance expenditures have decreased 1 percent per year since 1992. Existing transmission facilities were not designed for the current level of demand, resulting in an increased number of 'bottlenecks,' which increase costs to consumers and elevate the risk of blackouts."[17] It gave "Energy" or the "US Electric Power Grid" a D grade. The primary reason for alarm is inadequate investment in the transmission grid for an increasing national demand for electricity.

In August 2003, an electrical power failure hit the Midwest, Northeast, and portions of Canada. Several power plants and transmission lines went offline due to instability in the transmission system in three states. This led to greater instability in the regional power transmission system, and, within four hours, a rapid cascade of additional power plant and transmission line outages caused a large-scale blackout. The power failure affected nearly 50 million customers in the United States and Canada and numerous vital services and commerce, including air and ground transportation systems, the shutdown of drinking water and sewage processing systems, and failure of some emergency communication systems.[18]

Foreign Policy Vulnerability

In *National Security Consequences of US Oil Dependency*, John Deutch and James R. Schlesinger detail the foreign policy dependency. They charge that "the lack of sustained attention to energy issues is undercutting US foreign policy and US national security. Major energy suppliers—from Russia to Iran to Venezuela—have been increasingly able and willing to use their energy resources to pursue their strategic and political objectives. Major energy consumers—notably the United States, but other countries as well—are finding that their growing dependence on imported energy increases their strategic vulnerability and constrains security objectives.[19]

Foreign policy issues are daily concerns for the White House and the Department of State, but the DOD is typically the department called upon when foreign policy goes awry. In his article, "Energy Security: The New Threats in Latin America and Africa," David L. Goldwyn, a senior fellow at the Center for Strategic and International Studies, argues that current US energy dependency challenges US power in five ways. First, dependency on consuming imported oil makes many nations reluctant to join coalitions led by the United States to combat weapons proliferation, terrorism, or aggression. Examples include French, Russian, and Chinese resistance to sanctions on Iran; Chinese resistance to sanctions against Sudan; and US tolerance of Middle East repression that would otherwise have been sanctioned were it to occur in any other non-oil-producing part of the world.[20]

Second, high oil revenues in the hands of oil-exporting nations allow governments to act with impunity against their own people and work against the United States and its neighbors. Venezuelan president Hugo Chavez, Latin America's loudest anti-American cheerleader, has used oil revenue to build support for his economic vision by providing subsidized oil to neighboring countries and gaining advantage over them by purchasing bonds to finance their debt. Russian president Vladimir Putin has renationalized his energy sector, restricted foreign access to his pipeline system, and demanded open access to Europe. Iran has reduced its international debt and increased foreign reserves to prepare for possible sanctions. Goldwyn remarks that "Even Saudi Arabia's economic reform movement, born in the days of $10 oil in 1998, evaporated when oil reached $30 per barrel in 2000. Enrichment of America's competitors or adversaries harms US security interests in every part of the globe."[21]

Third, the global oil market is far from being a fair, free-market system. Governments that do not allow free-market access to develop, exploit, and expand supplies control most of the world's major oil reserves. Most free-market commodities allow the market supply to expand to meet demand. As oil prices rise, many governments are less receptive to foreign investment, preventing supply from responding to demand and driving prices even higher.[22] An increased price of imported goods increases the US trade deficit and exports wealth to foreign lands. In 2005, imported oil accounted for one-third of the country's $800 billion trade deficit.[23]

Fourth, the highly competitive world oil market enables the political competitiveness to undermine the fluidity and fairness of the market for available supplies. Goldwyn adds that "New competitors like China and India are trying to negotiate long term contracts (at market prices) to ensure they have supplies in the event of a crisis or supply disruption. . . . From an economic point of view it may not matter if China lends Angola $3 billion at low interest to gain part of an exploration project as long as the oil is produced. But China gains an enormous geopolitical advantage by this act."[24]

Fifth, the problem oil dependency creates for America and directly impacts the DOD is vulnerability to price volatility that results from supply and demand shocks.[25] From fall 2005 until gasoline prices started to decline in fall 2006, the price of gasoline had replaced the weather as America's favorite subject of conversation with a stranger. The price of standard crude oil on the New York Mercantile Exchange was under $25 per barrel in September 2003, but by 11 August 2005, the price had increased to more than $60 per barrel; the price topped out at a record $78.40 per barrel on 13 July 2006.[26] Experts attributed the spike in prices to many factors, including the war in Iraq, North Korea's missile launches, the crisis between Israel and Lebanon, Iranian nuclear brinkmanship, and Hurricane Katrina. None of these factors, except for the war in Iraq, could be controlled by the US government.

The global energy infrastructure built over the last century is quite fragile and was not designed with any vision of terrorist attacks or computer hackers in mind. The DOD must accept the fact that vulnerabilities exist and that bad actors eventually will exploit these vulnerabilities if corrective measures are not taken.

Notes

1. National Research Council, *Improving the Efficiency of Engines*, 89.
2. Blanchard, *Al Qaeda*, 12.
3. Parfomak, *Pipeline Safety and Security*, 1–2.
4. Ibid., 3.
5. Defense Energy Support Center, *DESC – Providing Energy to Train, to Fight . . . to WIN*, 88–89.
6. Donnelly, "Military Wants a More Fuel-Efficient HUMVEE," A1.
7. Blum, "Hackers Target U.S. Power."
8. Energy Information Administration, *Electric Power Annual 2005*, 3, 14, 45.
9. Department of Energy, *Electricity Delivery System*, 2.
10. Lovins and Lovins, *Brittle Power*, 123.

11. Ibid., 131.
12. Department of Energy, *Benefits of Using Mobile Transformers*, 11.
13. Blum, "Hackers Target U.S. Power."
14. Ibid.
15. Ibid.
16. Ibid.
17. American Society of Civil Engineers (ASCE), "Report Card for America's Infrastructure."
18. Ibid.
19. Deutch and Schlesinger, *National Security Consequences*, 3.
20. Goldwyn, "Energy Security," 441.
21. Ibid.
22. Ibid., 442.
23. Senate, "Energy Diplomacy and Security," 46.
24. Goldwyn, "Energy Security," 442.
25. Ibid.
26. TFC Commodity Charts Light Crude Oil (CL, NYMEX) Monthly Price Chart, http://futures.tradingcharts.com/chart/CO/M (accessed 20 February 2007).

Chapter 4

Energy Strategy for Improved Energy Security

Fans often have the image in their minds of a big hitter coming up with the bases loaded, two outs, and the home team three runs behind. The big hitter wins the game with a home run. We are addicted to home runs, but the outcome of a baseball game is usually determined by a combination of walks, stolen bases, errors, hit batsmen, and, yes, some doubles, triples, and home runs. There's also good pitching and solid fielding, so ball games are won by a wide array of events, each contributing to the result.

—George P. Shultz
Former Secretary of State

In the foreword of Amory Lovins' book, *Winning the Oil Endgame*, former secretary of state George P. Shultz uses a baseball analogy to describe how the United States needs to rely on a steady, incremental approach to move forward to reduce its addiction to foreign oil and secure the energy future. The solution for the Department of Defense (DOD) is no different.

Energy Strategy

Although many intelligent energy experts reside within the DOD and many outstanding efforts contribute to improve energy security, the DOD does not currently have a permanent organizational focal point or advocate for energy issues or a written, long-term energy strategy. The DOD needs both—an organizational structure to serve as the focal point for energy issues and an energy strategy that improves national security by decreasing US dependence on foreign oil, ensures access to critical energy requirements, maintains or improves combat capability, promotes research for future energy security, provides fiscal responsibility to the American taxpayer, and protects the environment.

Decreasing US dependence on foreign oil significantly can be done only by looking at the many ways the DOD can consume less petroleum-based fuel through greater efficiency, smarter processes, and diversification of fuel sources to include alternatives other than petroleum. Domestically controlled production of alternative fuels also will help to assure access to critical energy requirements. Additionally, the DOD must ensure resiliency of installation electricity supply through increased on-site renewable energy production, reduced dependence on the commercial electric grid, and the capability to operate at full capacity if a commercial grid power failure occurs.

Improved combat capability will result from the efficiency effects and lengthening the tether of fuel. Reduced logistics requirements energy costs will allow assets and funds to be diverted to combat needs and for hard-earned taxpayers' dollars to be spent more responsibly. Reduced consumption, increased alternative fuels, and renewable energy production will help preserve the environment through reduced carbon emissions and more efficient use of natural resources.

Implementing Strategy

A proud tradition in the US government dictates that when issues arise, a bureaucracy is created to deal with it. Larger problems are often treated with larger bureaucracies. Recent examples include the creation of the Department of Homeland Security and the director of National Intelligence to respond to the attacks of and intelligence failures associated with 11 September 2001 (9/11). Were there a national security incident involving DOD energy use, for example, a prolonged electrical power failure affecting DOD installations, Congress surely would impose a prescriptive organizational change in the department.

To prevent such an event and to initiate change on its own terms, the DOD must reshuffle its organizational portfolios to create a specific focal point or energy advocate in the OSD to create and implement a department-wide energy strategy. Using Secretary Shultz' baseball analogy, the team currently has no manager. The goal, of course, is not to identify such a vague need as "the DOD needs an energy czar" or create additional bureaucracy in the negative sense with an excessive number of administrators, red tape, and petty energy officials but instead to properly define the requirement and parse authority on energy issues to a specific individual with the authority to allocate resources and establish policy on energy security for the department. Authority is a zero-sum game. A new position with authority over energy issues cannot be established without taking authority from someone else.

United States Code, Title 10, *Armed Forces*, provides guidance on the structure of the Office of the Secretary of Defense:

TITLE 10—ARMED FORCES

Subtitle A—General Military Law

PART I--ORGANIZATION AND GENERAL MILITARY POWERS

CHAPTER 4—OFFICE OF THE SECRETARY OF DEFENSE

Sec. 131. Office of the Secretary of Defense

(a) There is in the Department of Defense an Office of the Secretary of Defense. The function of the Office is to assist the Secretary of Defense in carrying out his duties and responsibilities and to carry out such other duties as may be prescribed by law.

(b) The Office of the Secretary of Defense is composed of the following:

(1) The Deputy Secretary of Defense.

(2) The Under Secretaries of Defense, as follows:
(A) The Under Secretary of Defense for Acquisition, Technology, and Logistics.
(B) The Under Secretary of Defense for Policy.
(C) The Under Secretary of Defense (Comptroller).
(D) The Under Secretary of Defense for Personnel and Readiness.
(E) The Under Secretary of Defense for Intelligence.

(3) The Director of Defense Research and Engineering.

(4) The Assistant Secretaries of Defense.

(5) The Director of Operational Test and Evaluation.

(6) The General Counsel of the Department of Defense.

(7) The Inspector General of the Department of Defense.

(8) Such other offices and officials as may be established by law or the Secretary of Defense may establish or designate in the Office.[1]

A logical level to establish an energy-specific position would be at the assistant secretary of defense (ASD) level. An ASD either could report directly to the secretary of defense, as do the ASDs for Legislative and Public Affairs, or could be made subordinate to an undersecretary of defense (USD) like the ASD for Health Affairs (reports to USD for Personnel and Readiness).

The USD for Acquisition, Technology & Logistics (AT&L) already possesses most of the key organizational structure and expertise needed to create and implement a DOD energy strategy. For example, the deputy undersecretary of defense (DUSD) for Installations and Environment is responsible for energy management at DOD installations, and the director of Research and Engineering is responsible for new technologies that could lead the DOD away from oil dependence. Energy issues cannot be separated from the various research, installations, acquisition, and logistics functional areas under AT&L, but there can be comprehensive energy oversight. Since many of the existing energy fiefdoms reside under DUSDs and agency directors in AT&L, it would make sense to establish an oversight position at the higher level of ASD. Title 10 specifically authorizes the creation of nine ASDs and gives congressionally mandated job descriptions for five of them (Reserve Affairs; Homeland Defense; Special Operations and Low Intensity Conflict; Legislative Affairs; and Nuclear, Biological, and Chemical Defense Programs). Establishing an ASD for Energy Security beneath the USD (AT&L) would have to be authorized by Title 10. Specific duties, not necessary to be prescribed in Title 10 unless the position is directed by Congress, could follow the author's description as listed below.

1. There is an assistant secretary of defense for Energy Security, appointed from civilian life by the president and by and with the advice and consent of the Senate.
2. The assistant secretary is the principal adviser to the secretary and the undersecretary of defense for AT&L on Energy Security and energy issues within the DOD and is the principal energy official within the senior management of the DOD.
3. The assistant secretary shall perform such duties relating to Energy Security as the undersecretary of defense for AT&L may assign, including
    a. prescribing, by authority of the secretary of defense, policies and programs for the implementation of an en-

ergy strategy to enhance Department of Defense Energy Security and combat capability;

b. advising and assisting the secretary of defense, the deputy secretary of defense, and the undersecretary of defense for Acquisition, Technology, and Logistics by providing guidance to and consulting with the secretaries of the military departments, with respect to Energy Security of the DOD; and
c. monitoring and reviewing all energy programs in the DOD.

The ASD for Energy Security must oversee a comprehensive study and direct actions by the services to assure access to critical energy requirements. Vulnerabilities addressed in chapter 3 must be identified and eliminated where possible. This includes petroleum and electricity infrastructure servicing military installations and improving renewable energy production and back-up generator capability in the event of a long-term civilian grid power failure.

Additionally, the DOD should set aside funding to be allocated at the discretion of the ASD for Energy Security for energy-saving programs that do not compete well within the service budget drills. Funding for energy-saving programs exists to some extent for DOD facilities only, but funding must be expanded to include other energy-saving programs. Another funding tool, the Energy Savings Performance Contract (ESPC), allows federal agencies to contract to purchase facility energy-saving measures with an agreement between the contractor and the agency to use the funds saved by those measures to pay for the project. The ASD for Energy Security should aggressively pursue legislation to expand ESPC to other DOD energy programs, such as the aircraft reengining programs discussed elsewhere in this chapter. The Air Force likely would appreciate the chance to execute these programs but not at the expense of other programs such as the F-22. Supplemental funding or ESPCs for energy savings programs could be the catalyst for getting these programs over the budgetary hurdles.

The ASD for Energy Security must leverage existing energy efforts and studies and ensure appropriate actions are taken. A great deal of work already has been accomplished in the previously mentioned studies, and the ASD for Energy Security should monitor this work to ensure that proper actions are taken. Creating the ASD for Energy Security is the baseball equivalent of filling a vacant manager's position.

The National Defense Authorization Act of 2007, Section 360, specifically tasks the secretary of defense to submit to Congress, not later than 16 October 2007, a report to include the following concerns.

1. An assessment of the feasibility of designating a senior DOD official to be responsible for implementing the policy of improving fuel efficiency in weapons platforms;
2. A summary of recommendations from the reports of three recent DOD energy studies: the Energy Security Integrated Product Team (2006); the Defense Science Board Task Force on DOD Energy Strategy (2006); and the Defense Science Board Task Force on Improving Fuel Efficiency of Weapons Platforms (2001);
3. Steps DOD has taken to implement recommendations from the reports;
4. Additional steps planned to implement recommendations from the reports; and
5. Reasons the DOD has not implemented and does not plan to implement certain recommendations from the reports.

Leadership and Culture Change

Air Force colonel James C. Slife believes that "Leadership is about vision, inspiration, values, and culture. Management is about systems, processes, resources, and policies. Organizational structure can, by itself, preclude success, it cannot, by itself, ensure success."[2] True culture change of any large organization must start at the top. Edgar H. Schein is Sloan Fellows Professor of Management Emeritus and a senior lecturer at the Sloan School of Management at the Massachusetts Institute of Technology. In his book, *Organizational Culture and Leadership*, he tackles the complex question of how an existing culture can be changed—one of the toughest challenges of leadership.

According to Schein, as an organization matures, it develops a positive ideology and a set of myths about how it operates. The organization continues to operate by the shared tacit assumptions that have worked in practice, "and it is not unlikely that the espoused theories, the announced values of the organization come to be, to varying degrees, out of line with the actual assumptions that govern daily practice."[3] In the case of DOD energy use, this assumption would be the assumption that energy is cheap, plentiful, and for someone else to worry about.

Where these differences exist, scandal and myth explosion become relevant as mechanisms of culture change. Left to themselves, change will not occur "until the consequences of the actual operating assumptions create a public and visible scandal that cannot be hidden, avoided, or denied."[4] Recent examples include changes in National Aeronautics and Space Administration's (NASA) safety culture following the *Challenger* and *Columbia* disasters or the Army's recent health care shakeup following the exposure of substandard administrative handling of wounded soldiers and conditions at certain Walter Reed Army Medical Center facilities. The DOD cannot afford to wait for an energy-related scandal before initiating change.

Schein proposes that leaders systematically can set out to change how a large, mature organization operates. To recognize such change may involve varying degrees of culture change. In short, it involves unlearning old behaviors and relearning new behaviors, and this cannot be done unless some sense of threat, crisis, or dissatisfaction is present to start the process of unlearning and relearning.[5] He adds that "The change goal must be defined concretely in terms of the specific problem you are trying to fix, not as a 'culture change'. . . . Culture change is always transformative change that requires a period of unlearning that is psychologically painful."[6]

Pres. George W. Bush has addressed dependence on foreign oil as a national security issue in his 2006 and 2007 State of the Union addresses. Unfortunately, every president since Richard Nixon has had some initiative to improve energy security without much success. Any perceived threat either was not threatening enough or not long enough in duration to induce an American culture change with regard to energy.

Perhaps the current threat to energy security is different. The United States is more dependent than ever on foreign oil. Its relations with the Middle East are strained, and China and

India are booming economically with a corresponding need for energy.

An excellent way to demonstrate a DOD need for change is for the secretary of defense to deliver a high-profile speech on energy security at a public venue, such as a service academy graduation, to support the president's energy initiatives, highlight the importance of DOD energy security, and announce the goals of a new comprehensive DOD energy strategy and the establishment of the ASD for Energy Security. No one should doubt that the leadership at the highest levels is behind the transformation towards energy security. The secretary should challenge leaders at all levels in the department to create incentives, remove disincentives, and seek out bold and innovative ways to reduce energy consumption, improve processes and efficiencies, and diversify energy sources as a national security issue. The secretary also should make it clear that such showy, automatic solutions as lowering the thermostats in the winter and forcing people to wear jackets in their offices will not be tolerated as acceptable methods of reducing energy use.

There is little current incentive for DOD personnel to reduce energy consumption. In fact, there are disincentives in place. Most military leaders in an organization always looking for places to cut budgets and personnel quickly learn that doing without is a sure way to lose money or personnel. The Air Force Flying Hour Program serves as an example, as is shown later in this section.

A flying squadron commander who is allocated 8,000 flying hours to conduct his or her mission and keep his or her aircrews properly trained in their aircraft but manages on 7,600 hours can expect a 7,600-hour allocation next year. Instead of being rewarded for saving taxpayers' dollars, units perceive such cuts as punishment. The commonly accepted solution is to find a way to fly the hours at the end of the fiscal year vice falling short of the allocation. This is a "use it or lose it" culture.

Saving energy is difficult if you don't know how much you are using. Most military bases today do not measure energy consumption at each building. The Energy Policy Act of 2005, Section 103, directs federal agencies to meter electricity use in all (to the maximum extent practical) federal buildings by 1 October 2012, using advanced meters or metering devices that provide data at least daily. The DOD has a plan to meet this requirement, but under the "maximum extent practical" caveat, many older buildings never will be metered.[7] Commanders should monitor energy consumed at their facilities and set goals for energy reduction. Energy savings should be rewarded, and excessive consumption should be investigated and corrected.

The first step towards culture change occurs when top-level officials educate personnel and provide incentives and rewards to commanders who conduct their mission, properly train their personnel, and save flight hours (read energy) or question why the hangar doors are left open in the winter or why the office lights were left on overnight. The DOD will have affected a culture change when commanders instinctively know they are accountable for energy consumption, when they know efficiency is its own "effect" in increasing combat capability, and when they continually strive to improve efficiency because energy is a consideration in all military activities and operations. Only then will energy efficiency become a defining characteristic of DOD operations and facilities.

Innovation and Process Efficiencies

In March 2006, secretary of the Air Force, Hon. Michael W. Wynne, introduced Air Force Smart Operations 21 (AFSO 21), a dedicated effort to maximize value and minimize waste in Air Force operations. AFSO 21 is a leadership program for commanders and supervisors at all levels, looking at each process from beginning to end. It doesn't just look at *how* the Air Force can do each task better, but asks the tougher and more important questions: Why are things done a certain way? and, Is each of the tasks relevant, productive, and value-added?[8]

The Air Force has assembled an AFSO 21 team to evaluate the core mission area and "conduct air, space, and cyber operations" (CASCO). The CASCO team identified $750 million in potential fuel savings[9] by improving such processes as additional aircraft weight reduction (removal of non-critical equipment), increased use of simulators for flying training and currency, reduced aircraft rotations to Iraq and Afghanistan, closer basing of aircraft to operating areas, more direct aircraft routing through improved diplomatic overflight clearances, greater fuel-efficient ground operations, and an elimination of unnecessary air refueling.[10]

Headquarters Air Mobility Command (AMC), which is responsible for organizing, training, and equipping USAF air mobility platforms (C-5, C-17, etc.), is improving efficiency of flight operations by directing units to stop refueling aircraft without first knowing the required fuel load for the next mission. Air Force flying operations account for 82 percent of its fuel use, with mobility operations consuming the single largest slice (42 percent). Data collected on one C-17 unit conducting stateside operational missions showed aircraft departed with an average of 58,000 pounds more fuel than the mission required due to standard ramp fuel loads.[11] The cost to carry extra weight in aircraft is enormous. The AMC standard cost of 100 pounds of weight across the mobility air forces fleet is $680,000 each year or 1.42 million pounds of fuel.[12]

The ASD for Energy Security should lead a department-wide effort similar to AFSO 21 for fuel savings in other service aviation programs, maritime operations, ground vehicle operations, and facilities energy use. In baseball terms, this is simply playing smarter, like good base running, hitting the cutoff man, and throwing ahead of runners instead of throwing behind them.

Efficiency in Platforms—Aviation

Investing in efficiency is one of the most cost-effective ways to save energy. Recent advances in aviation technology have been significant. Boeing's new 787 Dreamliner represents a 70 percent improvement in fuel efficiency (cost/passenger mile) over their original 707 (KC-135) jet-transport-production aircraft.[13] The DOD should investigate factors that improve efficiency in aircraft and modify those that prove to be life cycle cost effective. In baseball terms, this is like a sacrifice bunt. Sacrifice the batter now (spend money on reengining) to move runners into scoring position (save money on fuel and gain efficiency/combat effectiveness later).

The low-hanging fruit for improving efficiency on older aircraft is reengining or modifying existing engines. This is particularly true for such large non-fighter aircraft as those seen in the commercial aviation market, where fuel costs currently exceed labor costs and have demanded higher efficiency engines in recent decades. Unfortunately, there is no corresponding commercial market for high-performance afterburning engines used on fighter aircraft.

Note, however, that reengining an aircraft is expensive and can affect all major aircraft systems and the training support structure. The cost of implementation may include reanalysis, redesign, or recertification of major aircraft systems to include cockpit controls and instrumentation, bleed air systems, hydraulic systems, electrical systems, aircraft structure, and developing and training new maintenance operations, publishing new technical manuals, training aircrews on new systems, and modifying training courseware and simulators as required. In short, reengining is no simple task.

Through a contract awarded in 1979, the Air Force successfully reengined 410 KC-135A Stratotankers, first delivered in 1957, to the KC-135R configuration. This effort yielded 50 percent more fuel offload capability, 25 percent increase in fuel efficiency, 25 percent decrease in operational cost, and a 96 percent noise reduction.[14] The reengined fleet of KC-135s saves the Air Force from 2.3 to 3.2 million barrels of fuel annually.[15]

In 2006 the Air Force tasked the National Research Council (NRC) to examine and assess options for improving engine efficiency of all large non-fighter aircraft in its fleet. Improved engine efficiency can result in an increase in performance, a decrease in fuel consumption, or both. For the purposes of the NRC report, the primary objective of modifying or reengining aircraft is to reduce fuel consumption. However, the report also highlighted several additional benefits that must be considered, including aircraft performance improvements, reduced maintenance, improved reliability and safety, and reduced environmental impact. Additionally, the report addressed the cost of modifying or reengining aircraft and timing as significant constraints. The report also maintained that "while decisions should be based on economic benefit/cost analysis, they must also consider some of the benefits that cannot be easily monetized, such as performance improvements and national security. It may be the case that a greater good argument prevails, with the decision being made on more than just economic grounds, and that the controlling variable is saving fuel—not at any cost but at a reasonable cost."[16]

Figure 4, taken from the NRC study, depicts selected large non-fighter aircraft potential fuel savings (based on a fuel price of $2.14 per gallon). It also shows the most favorable modification/reengine options in improved efficiency and reduced consumption based on 2005 utilization rates, expected remaining service life, and fleet size (represented by proportional-sized bubble diameter).[17]

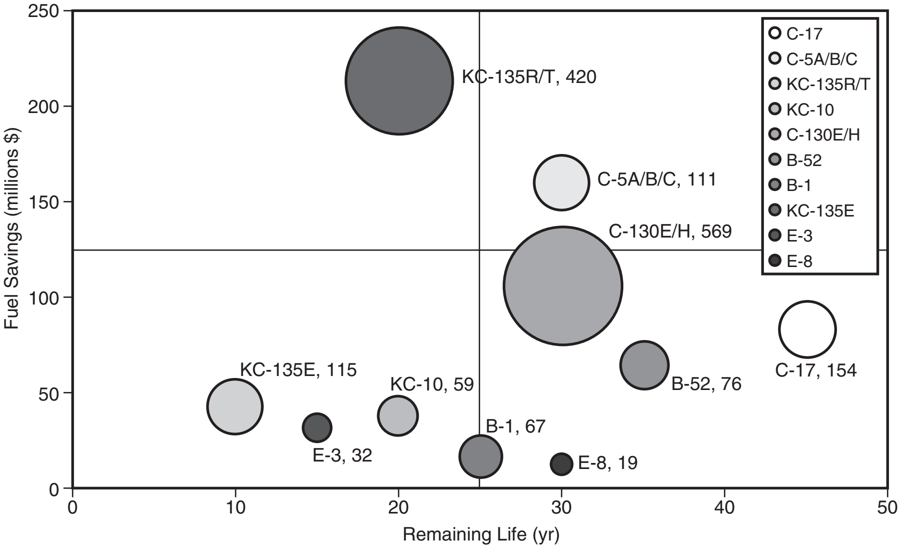


Figure 4. Engine efficiency options for large, non-fighter aircraft. (©National Academy of Sciences. Permission is granted for this material to be shared for noncommercial, educational purposes, provided that this notice appears on the reproduced materials, http://www.nap.edu/catalog.php?record_id=11837.)

The committee highlighted a number of modification and reengining options that deserve careful consideration and might pay for themselves. Key recommendations are listed below.

- The Air Force should study the potential upgrade of the KC-135R/T fleet with the fuel burn improvement modifications proposed under the Service Life Extension Program (SLEP) for the F108 engine.

- The Air Force should pursue reengining the C-130H on a priority basis, since this aircraft is one of the largest users of fuel in the Air Force inventory. The Air Force should use a competitive bid procurement process to provide the background for a decision on the C-130H models between the AE 2100 and PW150 engine options, either of which would appear to be acceptable on a technical and performance basis, and it should review the economics of engine efficiency upgrades to the older models with a shorter remaining service life.
- In general, where commercial engine/airframe counterparts exist (KC-10/DC-10, etc.), the Air Force engine and weapons system planners, managers, and policy makers should closely monitor the engine's original equipment manufacturers' and commercial operators' activities and actions relative to reengining and engine modification as a measure of the cost/benefit for these activities.
- The Air Force should approach reengining of the aircraft powered by the various models of the TF33 engine on a holistic basis with the goal of removing the engine(s) from the inventory.[18]

The case for replacing the TF33 family of engines is particularly compelling. The Air Force currently has approximately 2,300 TF33 engines of various models that were used mainly on the KC-135E, E-3 AWACS, E-8 JSTARS, and B-52H. The TF33 was designed in the 1950s and is one of the oldest engine families in the Air Force inventory. Since FY03, the TF33 depot overhaul cost has increased by 300 percent to $1.25 million per engine in FY06. The very long, on-wing lives of modern commercial transport engines (potentially 10,000 hours or more on-wing compared to from 1,500 to 2,000 hours for the TF33) would reduce the cost of engine ownership significantly.[19]

With the exception of the B-52H, all of the TF33-powered aircraft are KC-135 variants or derivatives. Given that the majority of the KC-135 fleet has already been reengined in the KC-135R program and the E-8 JSTARS is now in reengining source selection, a portion of the nonrecurring engineering costs may be shared among platforms rather than duplicated.[20] Eliminating TF33 engines from the inventory would dispose $800 million in TF33 inventory and the TF33 support structure of 188 personnel and 82,000 square feet of support real estate to be used for other Air Force needs.[21] The NRC report concluded that "Taken together, these considerations strongly suggest that TF33-powered aircraft should be considered as a group rather than subjected to the traditional approach—i.e., air-frame by airframe studies. In this case, the whole savings from reengining all TF33 aircraft may considerably exceed the sum of reengining the individual platform types."[22]

The Defense Science Board, sponsored by USD (AT&L), conducted a study by Gen Michael P. C. Cairns (USAF, retired) in late 2002 and produced an updated version in 2004 on reengining the USAF B-52H fleet. This study was the fourth look at reengining the B-52H fleet since 1996. The first three Air Force studies concluded reengining was not economically justifiable. However, several assumptions drove the decisions, including constant fuel prices, the assumption that engine depot repair costs would remain stable through 2037, the Air Force's judgment that required funding would lose out to higher priorities, and the possibility that premature B-52H retirement and force reductions would be unacceptable program risks.[23] The intent of this paper is not to challenge the USAF decision not to reengine the B-52H fleet but instead to highlight one example of what more efficient engines can provide for energy savings and other operational and environmental gains.

The DSB study concluded that B-52H reengining would reduce overall fuel consumption by about 35 percent and in-flight refueling demand from 50 to 66 percent. The DSB task force scenarios estimated overall savings of nearly $8 billion through 2037 in reduced fuel demand, including reduced demand on existing tanker assets.[24]

A modern turbofan engine on the B-52H also would yield significant aircraft performance and would result in a 46-percent increase in unrefuel range, according to Boeing estimates. For example, a 10,000 mile B-52H mission (United States to Afghanistan and return) would require only one in-flight refueling instead of two and require 158,000 pounds less fuel. On a typical Diego Garcia to Afghanistan mission, a 46 percent range increase would produce the combined benefits of accomplishing the mission with 66 percent reduced tanker demand, plus

4.7 hours of loiter time. Additionally, emissions of carbon dioxide, carbon monoxide, and smoke would decrease by 30 percent (oxides of nitrogen would increase by a factor of two), and community noise impacts would be reduced significantly.[25]

The available energy of its fuel limits any propulsion system. One pound of JP-8 jet fuel has enough energy to produce 7.2 horsepower for one hour. Thermal efficiency defines the amount of fuel-available energy that is converted to horsepower for a real engine. Present-day gas turbine engines can convert about 40 percent of the available fuel energy. Overall efficiency of jet propulsion systems defines how much of the fuel-available energy is converted to useful thrust. There are also inherent losses in converting mechanical power to jet thrust. Today's engines are constrained to provide either fuel efficiency or high performance. Modern high-bypass turbine engine transport aircraft are about 30 percent efficient in converting available fuel energy into thrust. Fighters and bombers typically convert from 20 to 25 percent useful thrust. Therefore, plenty of room is available for efficiency improvements in the gas turbine engine.[26]

Promising future engine-efficiency programs are under way in a cooperative government and industry effort. Versatile, affordable, advanced turbine engines (VAATE) is the national turbine-engine technology plan that will provide the future propulsion capability US war fighters need to combat changing threats to security. Comprised of all sectors of the DOD, National Aeronautics and Space Administration, the DOE, six major engine companies, and three airframe manufacturers, VAATE is a totally integrated, physics-based, turbine-engine technology program chaired by OSD. The program includes technical activities that will improve turbine-engine capabilities beyond those of a year 2000 baseline engine while reducing all facets of engine cost. VAATE is a three-phase technology program with a defined goal set to produce a 10X improvement in affordable turbine-engine capability by 2017. VAATE engines will reduce engine thrust-specific fuel consumption by as much as 25 percent.[27] VAATE represents the great things a promising young minor league baseball prospect will do.

The NRC is studying several other efficiency approaches to saving fuel by modifying existing aircraft, including aircraft winglets, laminar flow nacelles, optimization of operations, engine build practices, information use, and engine water washes.[28] Aircraft efficiency factors with promising potential for fuel savings on future designs include improved blended wing body designs, reduced weight through use of composite materials and more efficient structural design, and improved aircraft systems (e.g., reduced weights via increased electrical systems versus hydraulic and bleed air systems).

Efficiency in Platforms—Maritime

Like aircraft, maritime platforms have made progress in efficiency over the years. The Navy gained a 15 percent increase in fuel efficiency on selected ships by using stern flaps and bulbous-bow technology on surface ships. The stern flaps create lift to the aft portion of the ship and reduce propeller cavitations. This results in reduced hydrodynamic drag and improved efficiency. The Navy projects a 7.5 percent net annual fuel savings on *Arleigh Burke*–class guided missile Aegis destroyers of almost $195,000 per year for each ship. Use of the bulbous bow to reduce drag by lowering the wave-making resistance of the ship's hull can save an additional 4 percent in fuel use, with a yearly fuel savings of approximately 100,000 gallons per year for each ship.[29]

The Navy also is studying ways to convert fossil fuel-burning ships to nuclear power. As discussed in reengining aircraft, changing propulsion systems on a ship is no easy task and would include extensive redesign and training. For each class of ship, there is a corresponding price of oil where nuclear-powered propulsion becomes economically feasible.

The civilian shipping industry is also seeing significant efficiency improvements using silicon hull paints, which help to save up to 6 percent of fuel on container ships.[30] This could also have military applications.

Efficiency in Platforms—Ground Tactical Vehicles

Lovins argues in *Winning the Oil Endgame* that "the nearly 70-ton M1A2 Abrams main battle tank—the outstanding fighting machine of US armored forces—is propelled at up to 42 mph on- or 30 mph off-road by a 1,500-hp gas turbine, and averages around 0.3–0.6 mpg. Its 20–40 ton mpg is surprisingly close to the 42-ton mpg of today's average new light vehicle; the tank simply weighs 34 times as much, half for armor." He cautions, "But there's more to be done than improving its 1968 gas turbine: for 73 percent of its operating hours, Abrams idles that 1,100-kW gas turbine at less than 1 percent efficiency to run a 5kW 'hotel load'—ventilation, lights, cooling, and electronics. This, coupled with its inherent engine inefficiency, cuts Abrams' average fuel efficiency about in half, requiring extra fuel whose stockpiling for the Gulf War delayed the ground forces' readiness to fight by more than a month."[31]

The most important factor in reducing the demand for fuel in vehicles is the weight of the vehicle. Heavier vehicles simply require more energy to move. The DOD recognizes the potential energy-efficiency savings associated with lightweight materials and structures and is investing in materials research to provide high-performance ground vehicles to meet war-fighting needs and save energy.

The Naval Research Advisory Committee's April 2006 report, *Future Fuels*, recommended hybrid, electric-drive vehicles as the most effective and efficient way to lengthen the tether of fuel. The study found that fuel economy could improve by as much as 20 percent or more, enable highly maneuverable and agile vehicle traction control both on- and off-road, in covert or overt operations, and provide mobile electric power.

The DOD should strive to accelerate ongoing efforts, including using carbon-fiber reinforced composites, expanding the use of titanium (40 percent lighter than steel), rethinking the use of armor to protect the occupants of the vehicle rather than armoring the entire vehicle, and developing a hybrid electric architecture for tactical wheeled vehicles.

The incredibly high utilization rate of tactical wheeled vehicles in OIF and Operation Enduring Freedom is wearing out equipment that will soon need to be replaced. It would be preferable to develop and acquire a fuel-efficient replacement to the high mobility multipurpose wheeled vehicle (HMMWV or Humvee) now instead of refurbishing or buying new Humvees, which get only 4 miles per gallon in city driving conditions and 8 miles per gallon in highway driving conditions.[32] They are destined to be inefficient for their potential service life of 20 to 30 years.

Increase Supply/Diversify Sources

In coal-rich, oil-poor, pre–World War II Germany, Franz Fisher and Hans Tropsch developed a process to produce liquid hydrocarbon fuel from coal that supplied a substantial portion of Germany's fuel during the war. The Fischer-Tropsch (FT) process is a catalyzed chemical reaction in which syngas—carbon monoxide and hydrogen produced from the partial combustion of coal that has been gasified and combined with molecular oxygen—is converted into liquid hydrocarbons of various forms. Typical catalysts used are based on iron and cobalt. Liquid hydrocarbon fuels produced from coal gasification and the FT process are intrinsically clean, as sulfur and heavy metal contaminants are removed during the gasification process. The principal purpose of the FT process is to produce a synthetic petroleum substitute for use as synthetic lubrication oil or as synthetic fuel. The FT process can be used to produce liquid hydrocarbon fuel from virtually any carbon-containing feedstock, including low-grade tars, biomass, or shale oil; only the preprocessing steps would differ from the gasification process used with coal.[33]

Since the United States has the largest coal reserves in the world, synthetic fuel, or synfuel, made from coal is particularly appealing. Synfuel represents a domestically controlled resource with prices theoretically tied to the coal market instead of the world oil market.

South Africa has been producing synthetic fuel for decades, and many consider it a technology ready for commercialization. Why then, has the synfuel market not boomed and produced billions of gallons of fuel for US energy needs? Until recently, the answer has been financial risk.

Congress approved the Synthetic Liquid Fuels Act on 5 April 1944. The act authorized $30 million for a five-year effort for "the construction and operation of demonstration plants to produce synthetic liquid fuels from coal, oil shales, agricultural and forestry products, and other substances, in order to aid the prosecution of the war, to conserve and increase the oil resources of the Nation, and for other purposes."[34]

In 1948 Congress extended the project to eight years and doubled its funding to $60 million. In the end synthetic fuel from coal could not compete economically with gasoline made from crude oil, especially given the major oil reserve discoveries in the Middle East at the time. In 1953 Congress terminated funding and closed the plants.[35]

At the height of the 1979 oil crisis, when the United States imported approximately 25 percent of its crude oil, Pres. Jimmy Carter proposed an energy security corporation to use $88 billion of windfall profits tax on domestic oil producers to subsidize development of 2.5 million barrels per day of synthetic fuels production. After much debate, Congress passed the Energy Security Act of 1980. The law created a US synthetic fuel corporation with an initial budget of $17 billion. After four years, the corporation would submit a comprehensive strategy for congressional approval, where the balance of $68 billion would be made available. A combination of mismanagement, administrative change from President Carter to Pres. Ronald Reagan, and most significantly, crude oil prices falling from a 1981 peak of $70+ per barrel to $10 in 1986, effectively killed the US Synthetic Fuel Corporation.[36] Of the 67 projects proposed in 1981, only a few carried design efforts to maturity. Bad business risk became the stigma attached to synthetic fuels.

In 2006 the secretary of the Air Force directed a project to procure synthetic jet fuel for ground testing and, if ground tests were successful, flight testing.[37] In September 2006 a B-52 conducted a flight-test mission using a 50/50 blend of manufactured synthetic fuel and petroleum-based JP-8—or synfuel-blend—on two engines. In December 2006 an eight-engine test was successfully conducted. In January 2007, cold-weather testing was performed at Minot AFB, North Dakota. The last step in the testing and certification process was engine teardown and test data analysis. A B-52 certification signing ceremony was held at Edwards AFB, California, on 8 August 2007. The Air Force is committed to completing testing and certification of synfuels for its aircraft by early 2011 and aims to acquire 50 percent of the continental United States fuel from a synfuel-blend produced domestically by 2016. At current consumption rates, this equals to approximately 800 million gallons of synfuel-blend.[38]

The Air Force is standing up a program management office (PMO) to assume responsibility for the remainder of the testing and certification of the fleet. This transition from a research, design, and development program managed by Air Force Research Laboratory to a comprehensive program managed full time by the Aeronautical Systems Center (ASC) is a reflection of the size and complexity of the effort and the importance it has in the Air Force.

The PMO is meeting with all single managers responsible for aircraft engines, airframes, fuel systems, and ground equipment to inform them of the detailed testing and work conducted in the certification of the B-52. These meetings are intended to provide a complete understanding from the macrolevel to the smallest detail affecting operational safety. In addition, the single managers will be asked to provide their assessment of the necessary testing and certification work required to ensure that they are only certifying equipment not covered by the B-52 test and certification program. This process is called gap analysis and is expected to produce a disciplined and efficient certification program.

The Air Force is also collaborating extensively with the Commercial Aviation Alternative Fuels Initiative (CAAFI) that is represented by the Federal Aviation Administration, Air Transport Association, the Airports Council International–North America, and the Aerospace Industries Association. Since a number of aircraft are common to civilians and the military, the high bypass engine test information is being shared to reduce redundancy and facilitate expeditious certification. CAAFI seeks to certify all aircraft for the use of the 50/50 blend of Jet-A and synthetic fuel by 2008 and to certify aircraft for 100 percent synthetic fuel by 2010.[39]

This process certainly will not eliminate US dependence on foreign oil, but it is comparable to a double or triple in the George Shultz baseball analogy cited at the beginning of this chapter. Subsequent actions, such as proving the economic viability of synfuels or improving upon the FT process, could "bring these runners home" and further expand domestically produced energy supplies.

Could the world's single largest energy consumer be the catalyst to successfully launch a new synthetic fuel industry in the United States? Advocates say with government help, FT technology could supply 10 percent of US fuels within 20 years.[40]

A relatively small synthetic fuel plant, processing 17,000 tons of coal per day to produce 28,000 barrels of fuel per day, 750 tons of ammonia per day, and 475MW of net electrical power would cost approximately $3 billion.[41] Ten to 15 such plants could supply all of the DOD's fuel requirements.

Senators Jim Bunning and Barack Obama have introduced legislation to address the need to pull together the investors and the billions of dollars needed to build a synthetic fuel plant by expanding and enhancing the DOE loan guarantee program included in the Energy Policy Act of 2005. They also want to provide a new program of matching loans to address funding shortages for front-end engineering and design (capped at $20 million and a requirement for matching by non-federal money), expand investment tax credit and expensing provisions, and extend the fuel excise tax credit; provide funding for the DOD to purchase, test, and integrate synfuels into the military; authorize a study on synfuel storage in the Strategic Petroleum Reserve; and most importantly, to reduce financial risk associated with starting a US synthetic fuel industry, thus extending existing DOD contracting authority for up to 25 years.[42]

Long-term contracts move much of the financial risk from private investors to the American taxpayers. If there were a long-term decline in the price of oil, the DOD could potentially pay much higher prices for synthetic fuel than they otherwise would pay for petroleum products. In past years the DOD has not received the authority to enter into the 15- or 25-year deals industry wants.

In his keynote address to the March 2007 USAF Energy Forum in Washington, DC, Senator Bunning addressed the issue: "I believe the DOD should be authorized to pay a premium for high-quality, clean, domestic fuel. Long-term contracts will provide price certainty and allow for more consistent budgeting. These contracts will vary above and below market prices as world oil prices change during the life of a 25-year contract. I believe this is healthy and normal for long-term contracts."[43] Secretary Michael W. Wynne also addressed price stability at the Energy Forum: "Last year, the AF spent about $6.6 billion on aviation fuel; 1.6 billion dollars more than budgeted. In 2005, the fuel budget was $1.4 billion more than the previous year. We could have paid a supplier to build a dedicated coal, natural gas, or other derived fuel plant with this $3 billion in unbudgeted expense. Maybe then we could have a predictable cost for fuel."[44]

A coal-based synthetic fuel industry also has significant environmental burdens to overcome. Synfuel plants consume huge quantities of water, both as part of the coal-conversion process and for cooling. A typical plant consumes about 3.5 barrels of water for each barrel of synthetic fuel produced. Water is a potentially limiting factor for building synfuel plants in many coal-rich western states like Wyoming and Montana.[45]

An even bigger environmental issue is the amount of carbon dioxide (CO^2) produced by refining coal. This amount can range from 50 to 100 percent higher than the range from refining petroleum.[46] Advocates for synfuel point out the CO^2 can be captured and used for "enhanced oil recovery" by pumping the captured CO^2 into oil wells to retrieve otherwise unobtainable oil or oil sequestered in underground saline aquifers or other "storage" locations to prevent addition of CO^2 from becoming an ever-increasing GHG problem. Skeptics quickly point out that carbon capture and sequestration have never been proven on any large scale, and if such attempts were made, they would surely add to the cost of synfuel production.

Global warming due to GHG emissions has become the political 500-pound gorilla that cannot be ignored. Secretary Wynne acknowledged this in his address to the USAF Energy Forum, saying:

> The big issue is the sequestration of large amounts of carbon dioxide before it's released into the atmosphere. The DOE National Energy Technology Laboratory and several others are now working on the development of carbon capture technology that approaches 90%.
>
> Our team at Wright-Patterson also is working on a study with DOE to find the right mix of biomass and coal to reduce CO^2 emissions starting with the feedstock.
>
> We aim to be good stewards of the environment and yet push for the production and purchase of domestically produced synfuel from plants that use coal, natural gas or other derivation that incorporate greenhouse gas reduction processes to provide the right fuel in the right manner.[47]

The DOD could not only be the catalyst for the synthetic fuel industry in the United States, it could also promote US carbon capture and sequestration on an unprecedented scale. The

DOD should not support any synfuel initiatives that do not responsibly handle CO^2 emissions.

Ethanol is an important alternative to petroleum-based gasoline in the larger national strategy to reduce oil consumption, and the DOD should follow government guidelines in purchasing new non-tactical vehicles capable of operating on ethanol or other alternatives to gasoline. However, gasoline represents 1.1 percent of DOD energy costs, and aggressive pursuit of ethanol for the DOD will not make a significant difference.

DOD Facilities and Renewable/Nuclear Energy Sources

As discussed in chapter 2, the DOD facilities energy management could serve as a model for other federal agencies. The DUSD (I&E) manages an excellent facilities energy program. Facilities are unique in that efficient facilities can reduce energy demand, and renewable energy initiatives on or near DOD installations can also increase supply and diversify sources.

The DOD is one of the major leaders of the federal government in renewable energy, receiving about 9 percent of its electricity from renewable sources in FY 2005 (national average is 6 percent) and has a goal of 25 percent of its electricity from renewable sources by 2025.[48]

Why not a more aggressive goal? The DOD should set a goal of being a net-zero energy consumer at its facilities by 2030. The path to net-zero energy consumption is through expanded production of renewable, and possibly nuclear, energy sources at or near the DOD installations.

Several DOD installations are already exceeding the existing 25 percent renewable goal. Dyess AFB, Texas, is operating 100 percent on renewable energy, with Minot AFB, Montana, and Fairchild AFB, Washington, not far behind with 95.7 percent and 99.6 percent, respectively.

Other energy-saving or renewable energy projects already are established or under way at many DOD installations. At Nellis AFB, Nevada, the Air Force recently awarded a contract to build the largest photovoltaic solar farm in the world that is on track to generate 18MW in late 2008.[49] A 2004 Sandia National Laboratory study concluded that nearly all DOD installations have potential for one or more economically viable solar-energy projects with potential savings of 10 percent in electricity and 14 percent in natural gas.[50]

Geothermal energy has been a success story for the Navy. Geothermal energy is found in underground pockets of steam, hot water, and hot, dry rocks. Steam and hot water can be extracted from underground reservoirs to power steam turbines, which drive generators and produce electricity. Lower intensity geothermal resources are used for such direct-use applications as space heating and by geothermal heat pumps to heat and cool buildings.

The Navy has four privately built, owned, and operated geothermal power plants at Naval Air Warfare Center, China Lake, California,[51] and is building another facility at Naval Air Station, Fallon, Nevada. The private company sells the electricity to a utility company and pays the Navy. The Navy has received an average of $14.7 million annually from 1987 to 2003. The Navy spent about two-thirds of its geothermal revenues on energy-conservation projects, including solar-energy systems. About one-third of the revenues funded the overhead costs of the Navy's Geothermal Program Office. The geothermal plant at China Lake has been producing 345,000 MWh of electricity per year since 1990.[52]

The DOD has identified four additional installations as good candidates for geothermal power generation that might be commercially viable, third-party funded, producers of an average of 40 megawatts (Mwa) of electricity. Six to eight additional installations have hot water potential and will be researched further.[53]

Geothermal heat pumps are similar to ordinary heat pumps but use the ground instead of outside air to provide heating, air-conditioning, and, in most cases, hot water. Because they use the earth's natural heat, they are among the most efficient and comfortable heating and cooling technologies currently available. The services have installed 10,356 geothermal heat pumps among 24 different installations since 1993.[54]

In 2005 Naval Station Guantanamo Bay brought online the world's largest wind farm/diesel hybrid-power system. The plant is rated at 3.8 MW, is improving installation grid reliability, providing 25 percent of the base's power requirements; and saving the Navy $1.2 million annually.[55]

Since 1997 the Air Force has installed five wind-generation facilities, producing 8,400 KW of electricity. The Army has two small wind facilities, generating 335 KW, and the Navy has one wind facility at San Clemente Island, California, rated at 675 KW.[56] The DOD has identified an additional 109 facilities with the potential to produce an additional 70 MWa in wind energy.[57]

Renewable energy production at DOD facilities is growing and must continue to grow to assure access to critical energy requirements. Renewable energy diversifies energy sources and provides cost-effective, environmentally responsible energy to DOD facilities.

Nuclear Power

Another more controversial energy source with great potential to provide assured access to electricity for DOD installations is nuclear power. Secretary of energy, Sam Bodman, announced the Global Nuclear Energy Strategic Partnership (GNEP) in February 2006 as part of President Bush's Advanced Energy Initiative that he highlighted in his 2006 State of the Union address.

GNEP proposes "to work with other nations to develop and deploy advanced nuclear recycling and reactor technologies. This initiative will help to provide reliable, emission-free energy with less of the waste burden of older technologies and without making available separated plutonium that could be used by rogue states or terrorists for nuclear weapons. These new technologies will make possible a dramatic expansion of safe, clean nuclear energy to help meet the growing global energy demand."[58]

In short, GNEP seeks to expand nuclear power capabilities with advanced technologies to effectively and safely recycle spent nuclear fuel without producing separated plutonium. Once the technology is demonstrated, it can be exported to other countries.

If GNEP proceeds as planned, DOE will have to test and validate these new nuclear technologies. Larger DOD installations, especially those with limited renewable energy capabilities, could provide the DOE secure sites to validate the new technologies before sending them overseas. The DOD would gain nuclear-powered installations independent from the vulnerable, fragile commercial electric grid. Additionally, the DOD could provide surplus power to surrounding civilian communities.

The process likely will be a slow one, but the DOD can develop a comprehensive energy strategy and create an organizational structure for implementation. Through culture change, process innovations, efficiencies, and alternative energy sources, the DOD can retool itself with regard to energy.

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Chapter 5

Conclusion

> *For more than two decades, federal energy policy has been afflicted by paralysis. Although much energy legislation has been passed into law during this period, America's energy security has grown worse with each passing year. This deteriorating condition has created enormous economic and national security vulnerabilities. . . .*
>
> *The time for action arrived long ago. We must not waste another moment.*
>
> —Energy Security Leadership Council
> *Recommendations to the Nation on Reducing US Oil Dependence*
> December 2006

This paper has attempted objectively to address the US national security problem of deteriorating energy security from a Department of Defense (DOD) perspective. Energy is the lifeblood of the US economy and the key enabler of US military combat power.

The United States' unique ability to project military power anywhere on the globe requires incredible quantities of liquid hydrocarbon fuel. The primary source of fuel is imported oil from an economically and politically unstable world oil market.

The true cost of fuel is much more than it appears on the purchasing receipt. The DOD's never-ending need for fuel comes with a high price tag that includes not only the bulk purchase price of the fuel itself but also the cost of a fuel logistics system that includes tens of thousands of personnel, storage facilities, tanker trucks, and such major weapons systems as the KC-135, whose primary mission is to deliver fuel. Additionally, fuel has a significant cost in combat capability that is almost impossible to quantify.

Numerous outstanding energy programs abound within the Department of Defense. Rising energy costs have given new emphasis to saving fuel in each of the services, and the DOD facilities energy management program is a model for the federal government. Recent energy studies by military and energy experts provide volumes of recommendations to improve efficiency and save energy. However, there is no existing comprehensive DOD energy strategy, and there is no single energy senior official or energy advocate in the department.

The military's dependence on vast amounts of fuel and electricity creates vulnerabilities. Disruption in the flow of fuel and electricity due to natural disaster, sabotage, or physical attack on the petroleum or electricity infrastructure cannot be dismissed as an unlikely event. Also, that so much of the United States' and other countries' energy needs rely on imported oil creates foreign policy and economic vulnerability.

To improve energy security, the DOD needs a comprehensive energy strategy that improves national security by decreasing US dependence on foreign oil, ensures access to critical energy requirements, maintains or improves combat capability, promotes research for future energy security, is fiscally responsible to the American taxpayer, and protects the environment. Also required is an organizational structure to implement that strategy through the establishment of an ASD for Energy Security with policy and resource authority to serve as the senior official for energy issues in the department. The ASD for Energy Security must implement the department's energy strategy through leadership and culture change to make energy a consideration in all military actions and operations, innovation and process efficiencies, as well as efficiency improvements in platforms and facilities to reduce energy demand, and increased energy supply by way of alternative fuels and renewable energy programs.

The DOD can lead the way in transforming the manner in which the United States consumes and produces energy. In the 1985 movie *Back to the Future*, scientist Dr. Emmett Brown returns from the year 2015 with a 1980's vintage vehicle modified with a Mr. Fusion device creating huge amounts of energy from organic material found in common household garbage. The year 2015 is only eight years away, and there is no evidence Mr. Fusion or any major scientific breakthrough will make oil obsolete inside the next 30 years. Mr. Fusion represents the fantasy of the game-winning home run. In reality, few home runs exist to reduce the United States' addiction to foreign oil.

Improving energy security must be done through a steady, incremental approach that is not tied to individual personalities, specific military leaders, or partisan political administrations. Securing the energy future of the DOD is a prerequisite to ensuring that the United States remains the world's preeminent global power.

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